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CALGARTH PARK.

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AN
E S S A Y
ON THE
BATH WATERS.

In F O U R P A R T S.

C O N T A I N I N G

A Prefatory INTRODUCTION on the STUDY
of MINERAL WATERS in General.

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| PART I. An Account of
their possible Impreg-
nations. | Application of the fore-
going Rules, to the Dis-
covery of their Con-
tents. |
| II. The most approved
Means to be used for
the Discovery of their
Contents. | IV. An Application of
the Whole to the Prac-
tice of Pharmacy and
Medicine. |
| III. Experiments on the
Bath Waters, with an | |

By WILLIAM FALCONER, of Bath, M.D.

Neque vero inficiantur Experimenta quoque esse
necessaria ; ne ad hæc quidem aditum fieri potuisse,
nisi ab aliquâ ratione, contendunt. CELSUS.

L O N D O N,
Printed for T. LOWNDES, in Fleet Street.
MDCCCLXX.

22784

JOHN FOTHERGILL, M.D.



T O

JOHN FOTHERGILL, M.D.

DEDICATIONS are generally offered to rank and fortune alone, though when these are united with learning and abilities, they have certainly a stronger claim to our regard. For this reason I chuse to deviate from the usual course, and address the following treatise to one of the first Names in the science and practice of medicine; as, whatever may be the fate of the work itself, the public must approve my choice of a Patron. Not but I must confess I was partly swayed by a private motive, wherein my silence might justly be deemed ingratitude. Your kind concern for my welfare, and the interest you took in recommending me

iv D E D I C A T I O N.

to this place, would call for my warmest acknowledgments, were you less distinguished in the profession. Permit me then to offer to your notice this small Tract, and to join to so respectable a name as Dr. FOTHERGILL's, that of

his faithful,

and obliged friend,

Bath,
Aug. 1,
1770.

WILLIAM FALCONER.

INTRODUCTION.

On the STUDY of MINERAL WATERS *in general.*

IN the present improved state of medical knowledge, it seems remarkable, that so little progress should have been made in so important a branch of it, as that of the investigation of the Nature and Qualities of Mineral Waters. Books, indeed, have not been wanting, as upwards of two hundred volumes have been written on this subject only. The accounts, however, transmitted to us, by the generality of these Writers, are very little to be depended on, as they are mostly filled with instances of the grossest ignorance, or

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misrepre-

misrepresentation. Bold, however, as this assertion may appear, we still think that, on examination, it will appear well founded, and believe that in the future part of our Work, such instances of this will be produced, as will leave the Reader little reason to doubt its truth.

We would not have it here understood, that we mean this as a reflection on all the books, without exception, that have been written on the subject; we are willing and ready to acknowledge several useful and important discoveries, which are to be found in works of this kind. It must, nevertheless, be owned, that, considering the great advances made in the other branches of the science of physic, and in that especially which would most assist discoveries of this kind, this in particular has not been improved in proportion with the rest. A certain ingenious Writer, a native of a neighbouring kingdom, who has included in his work a Dissertation on the celebrated Waters which

which we propose as the subject of the ensuing pages, has carried his reflections on this subject to a great length, and made many severe observations on the Faculty resident there, for their ignorance of the principal remedy in their *Materia Medica*. How far this may be true, does not become us to determine; certain it is, however, that a decency of language impeaches no truth; and had the Author kept to that, his work would, probably, have found that reception in the world, which the ingenious discoveries it contains entitle it to. We hope, however, that our Work will be as little obvious to objections of this kind as the nature of the thing will admit of. Opinions, indeed, and some of those, perhaps, of a pretty general nature, will be found disputed; but we hope it will be done in such a manner, as not to give offence to those who have written in support of them.—When opinions alone are controverted, it may be alledged, that no apology is necessary, as a certain degree of candour

ought to be the inseparable attendant on learning; and that no man of science should be ashamed to receive information from whatever channel it may be derived.—Specious, however, as this argument may seem, the practice of the world is widely different. Disputes of this nature have been generally managed with great acrimony, and have not infrequently degenerated from mere literary controversies into personal satyr and invective. This observation, though particularly true in this instance, is not confined to physic, it having been an old general remark, that men are at least as tenacious of their opinions as their property. We are too well satisfied of our own imperfections, to desire to enter into disputes of this nature, and are ready to own, that, however probable our Theory may seem, it is by no means, even in our own opinion, free from objections. A consciousness of this will, we hope, make us ready to receive any information, or acknowledge any error, we have made.

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One merit, however, we hope we may pretend to, which is, that we have falsified no fact in favour of, nor suppressed any circumstance in our experiments, that might make against our opinions. When any such have occurred, we have related them faithfully, and, as far as reason, or a just probability would support us, endeavoured to reconcile them with our Theory.

We have not, likewise, taken any experiment on the credit of others, but have repeatedly made all those here related. How far we have succeeded, the world must judge; we hope, however, for some indulgence, as our Work is composed, in a great measure, on a new plan.

We shall now proceed to speak of the causes which have prevented, or at least retarded, the improvements we might have expected to have seen in this branch of science. The principal of which are the following.

1. The want of chemical knowledge. That a certain degree of chemical knowledge is necessary to those who propose to investigate the impregnations and qualities of Mineral Waters, will scarce be denied. As a proof, however, of it, if we look into the books written on this subject, while that branch of knowledge was little cultivated, and, of course, few improvements made; or into those of later date, whose Authors were defective in that science, we shall be abundantly convinced of the truth of this assertion.

We there read of impregnations of Waters with substances, which we know are (in the state they are presented to us by nature, and, of course, the state in which they are generally exposed to the action of the Waters) indissoluble in a watery fluid; or else of such substances which, although soluble in water, we know to be mere creatures of Art only, and, of course, not to be expected to be met with among the operations of Nature.

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Experience, likewise, justifies this Theory, and has proved most of those boasted impregnations to have existed only in the imagination of those who have made the assertion, and has reduced the number of the real and possible impregnations into a much smaller compass than the Advocates for Mineral Waters would be willing to allow.

We must not, however, too rashly attempt to set bounds to the operations of Nature, as several surprising and uncommon phænomena have been produced by means that we are ignorant of. Subterraneous fires, earthquakes, &c. numerous marks of which we see in many fossil appearances, often interrupt the course of Nature, and sometimes imitate, and at others form, the same productions with those which had issued from the hands of the most elaborate Chemist.

Nor must we always deny the impregnation of Waters with substances, from a pre-conceived opinion of their indissolubility

lubility in a watery menstruum; as many bodies are capable of so minute a diffusion through the body of a fluid, as to produce the same effects on the body, as they would have done in a state of solution; and, by that means, bring them under our definition of Medicated or Mineral Waters.

Neither, on the other hand, must we attribute too much to the dissolvent power of either simple water, or water when combined with such substances as it might meet with in the bowels of the earth, and which might increase its solvent effects, from a too great confidence in experiment. The circumstances of these are oftentimes widely different, and many productions are exhibited which vary greatly from those which our Theory would, at first sight, lead us to imagine; and others, which, from the great frequency of their component parts in the bowels of the earth, we might expect often to meet with in these researches, are seldom, if ever seen.

seen. We should be sorry, however, to have it inferred from hence, that we mean to depreciate the advantage of an accurate knowledge of chemistry, to those who are desirous of being acquainted with the history and use of Mineral Waters. Our intention is just the reverse; as we mean only to inculcate the use of an intimate knowledge of the principles of that science to every one of those who make this branch of medicine their study; as by that means he would be enabled to explain many appearances in nature, which seem different from, or even contradictory to, those which he had seen in apparently similar circumstances produced in the course of experiment, and which would perplex and confound one, who had only a superficial knowledge of the subject.

Many phænomena of this kind, we frankly own, have hitherto eluded the attempts of the most accurate and ingenious Chemists, to reconcile with their general principles; but as many of these have

been satisfactorily explained on a rational and coherent theory, and many appearances, seemingly contradictory, have been found to proceed from the same general cause, we may reasonably expect that the remainder may not prove utterly irreconcilable with our general system.

This, we hope, will prove a sufficient answer to those, who alledge that all attempts to discover the properties or effects of Mineral Waters on the human body, by chemical experiment, or analysis, are vain and insignificant, as there are many effects produced by them, which are not to be accounted for from any discoverable impregnation. We may reply to this, moreover, that several such there are still, and many more there were, formerly, whose effects seemed equally inexplicable.

Later experience has, however, demonstrated, that they are not all, at least, equally inscrutable; and as many of their effects have, by the assistance of chemistry, been explained on just and rational principles

ples of physic, what reason have we to despair that the remainder will, in time, be rendered equally clear?

To assert the contrary, would, were it applied equally to every branch of learning, preclude all search whatever; and, had it been formerly observed, would have hindered us of many of the useful and important discoveries we now enjoy.

An accurate knowledge of chemistry is likewise requisite in the examination of waters, to distinguish their original contents from those which are only the product of the experiments. From inattention to this circumstance, many mistakes have been committed, and many supposed discoveries have been made, of impregnations which never had any existence in the water before these were made.

2dly, Abuse and confusion of terms. This cause is nearly connected with the former, and proceeds, in a great measure, from the same origin; it having been an old

observation, that no science ever arrives at any considerable degree of perfection until its terms are accurately defined. If this rule holds general, we may pronounce this branch of knowledge to be at an exceeding low ebb, as there are scarcely two Writers on the subject of Mineral Waters, who have applied the same signification to similar expressions. It is, indeed, greatly to be doubted, if the Authors themselves had any positive ideas affixed to many of their terms, as they seem to be more frequently drawn from some possible, or, as their fancy might suggest, probable production, than from experiment tending to prove that such facts had really happened. This imperfection is justly charged on most of the antient Writers, and, indeed, was more pardonable in them than in many of their successors the moderns, who, notwithstanding they have wrote since more accurate, and explicit ideas were affixed to chemical terms, have still pursued the same unintelligible path with their predecessors. A late Writer of a voluminous
Treatise

Treatise on this subject has been grievously faulty in this respect, as many of his terms are inexplicable, others contradictory, and no small share of the remainder scarcely differing more from one another, than they do from those things which, from a view of their name, we should imagine they were intended to express.

Many of these Writers, like the Alchemists of old, have made a notable use of these confused and unintelligible terms, in order to cover their own ignorance; justly supposing that no one could object to terms, however unintelligible, which the custom of their predecessors had established, the very obscurity of which would lead many to believe implicitly in the sagacity and learning of the Author, while the means of its detection must be in the hands of few, and those, perhaps, too deeply interested to make the discovery.

Had this been properly attended to formerly, we should, in all probability, have seen many of the unmeaning and un-
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intelligible terms, which now disgrace this branch of learning, exploded, and new and explicit ones substituted in their place.

3dly, Want of method has been likewise a principal source of this obscurity, as that necessarily produces circumlocution, and not infrequently confusion.

For want of this, many of our Authors ideas appear so dark and unintelligible, and, probably, from a consciousness of it, were unwilling to part with terms so well adapted to them, being desirous, like the Painter of old, to cover with a veil what they were unable to express.

4thly, Lucre of gain, likewise, has been the occasion of much ignorance, as well as falshood and misrepresentation on this subject. The Practitioners from whom they might be chiefly expected, have been fearful of making, and still more of disclosing, the event of experiments made on the Mineral Waters which they attended, lest
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their impregnations should be discovered to be such as might be easily imitable in equal perfection by the hand of art, and by that means deprive themselves of many of their lucrative sources, by preventing the resort of people to a place for a thing so easily procurable at home.

Another reason, and perhaps a more justifiable one, is, that since a patient's good opinion of the efficacy of his medicines, is, in many cases, necessary, and at all times favourable to his cure, by keeping up his spirits, and securing his observation of the Physician's directions; should many of these boasted arcana, however efficacious in practice, be at once laid open, and discovered to be no more than the most common and simple substances, it might diminish his confidence in the remedy, and by that means deprive him of many of the advantages otherwise to be expected from it. They were, therefore, unwilling to encourage scrutinies of this kind, being
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contented with a few practical observations on the effects of the Waters, and desirous that the chemical discovery of their contents should, like the Roman Palladium, remain locked up in the most secret part of the Temple, scarce to be looked on even by the Priests themselves.

A celebrated Writer on this subject, has carried his arguments on this head much farther, and has brought several grievous accusations against the faculty of Physic; as having, for lucrative motives, so misrepresented or falsified the qualities of the Waters where they resided, as to adapt them to every disorder, or state of it, incident to the human body. Were this charge true in its full extent, grievous indeed would be the imputation; as it would be reducing the principles of their profession to the standard of the lowest empiricism; and, what is of still more consequence, how melancholy must be the situation of the generality of those who apply to such practitioners for relief! To
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such, indeed, the advice of a late great and worthy Physician might be well applied—To peruse the Sixth Commandment. We are, however, fully satisfied that this Author has carried his reflections to a very unjustifiable length. Some few might perhaps be found, to whom such an imputation might be applicable, as it can never be expected that the professors of medicine should, more than other men, be uniformly, and without exception, just and honest. But we are well satisfied, that the number of these is very small, in comparison with those who would even shudder at the thought.—Some prejudice, perhaps, is inseparable from our nature; it is not therefore to be expected, that our profession alone should be divested of it. Many practitioners, seeing the good effects of the Waters at which they resided, might be tempted to extend their use to more cases than their unprejudiced reasoning might fully justify. But is not this the case with the profession in general? What practitioner can safely assert he has not some partiality
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for a particular medicine above the rest? I believe few can avow it; and, if they should be so blind to their own prejudices, those who would examine their practice would soon make the discovery for them.

Prejudice of opinion, likewise, in favour of some particular theory, has misled many of the Writers on this subject. Many had formed their opinions before they made their experiments. It is probable, therefore, that many of those which seemed contrary to their opinion were suppressed, or misrepresented; while others, that seemed to favour it, were carefully remarked.

It is a common complaint, likewise, of books of this kind, that they seem to be written to the learned only; their meaning being so enveloped in terms of art, as to render them unintelligible to the rest of the world. This evil is, in some measure, a necessary one, as every science has peculiar technical terms belonging to it, without which we should not be able to give a clear idea of what we mean
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to express, without much circumlocution and tautology. This, however, by the antient Writers was carried to a very extravagant length, insomuch that they could scarce express the most simple idea, without the use of some abstruse technical term. Later improvements have, however, greatly diminished this formidable host, whereby the avenues to this branch of learning were formerly so strongly barricadoed, and has reduced them to a few, and those simple, expressive, and easily understood.

The use of an accurate chemical examination of the Waters, will, we hope, want no proof with men of learning and candour. Some cavils have, however, been frequently raised against any attempts of this kind, as being impossible to be brought to the desired degree of perfection, and therefore more apt to mislead, by substituting an uncertain or false theory, in room of an approved method, which time and experience had confirmed. The first of these objections has been, as we hope,

hope, already removed: And we would farther ask, Whether a search into the causes of effects, is unworthy the Physician, or Philosopher?

To the second we would answer, that no attempt is made to overthrow the good effects of the Waters in those cases which experience has justified, nor to extol their use in others which it has condemned. We are far from wishing to see a system of physic, or indeed the application of any particular medicine, founded on theory only, independent of practice. But is not a search into the causes of effects consistent with a due regard to practical knowledge? Do they not mutually illustrate one another? But we hope it is needless to pursue this argument farther. We will venture, however, to point out a few of the advantages which might accrue to the publick from a work of this kind, if accurately performed.

Were the contents of the Waters ascertained, it would enable the Physician to form a better judgment of their use in
physic,

physic, from a comparison of the effects on the human body, of the same, or similar substances, used as articles of medicine, with which the Water is impregnated, with the Waters themselves.— Might not this extend their use to many cases in which their efficacy is at present unknown, and instruct us in a better method of administering them in others, in which their good effects are acknowledged? Would it not be of service to those practitioners, who reside in distant places, who have had no opportunity of making experiments on, or of seeing the effects of, the Waters? Would they not then be enabled to judge of the proper application of these Waters in certain disorders, from analogy of the effects of the same, or similar substances with which they are acquainted? It is needless to expatiate on the use of this. A perfect knowledge of the chemical contents of the Waters would be of great service likewise to the practising Physician at the place.

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Most of the Mineral Waters are very apt to have their component parts separated, (which destroys their original effect,) on admixture of any foreign body. As it is often judged necessary to take some medicines along with, and frequently in, the Waters, a knowledge of this kind would instruct us in the choice of these, either to select such as would least alter their original nature, or else, from a knowledge of the compound formed by the medicine and the waters, to enable us to form some judgment of the effects likely to be produced by such a combination.

We shall now proceed to give the plan of our work ; and, first, we shall premise an account of Mineral Waters in general, and of those substances with which they are capable of being impregnated.

Secondly, We shall give an account of the most approved means to be used for discovering these impregnations.

Thirdly, We shall relate our experiments made on the Bath Waters, and endeavour

to apply the foregoing rules to the discovery of their contents.

Lastly, We shall make a brief application of the whole, to the practice of Pharmacy and Medicine.

PART

P A R T I.

WATER has been divided by the Chemical Writers into two kinds, but this is not quite correct, as we know but one kind of Water. Whether this Water be an element, or a compound, is not at present to our purpose to enquire. It seems, however, to have as good a title to the epithet of elementary as most bodies. It is a body that has fluidity and firmness in different circumstances, and is particularly disposed with respect to oily bodies.

Water, as it is capable of dissolving many substances, may, from a perfectly pure state to that of the greatest impurity, undergo various degrees of impregnation. Hence it is divided into *simple*, or *common*, and *compound*, or *mineral*.

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This division must be rather imperfect : First, because we know no Water perfectly free of some degree of impregnation ; and, secondly, as this division is only from different degrees of the same quality, it must, consequently, be inaccurate.

But by Common Water they would understand such, whose impregnation is not obvious to the taste or smell, and which has no sensible action on the human body.

By Mineral, where it has the contrary properties.

Even in Common Water, according to this division, there are various impregnations, which may be chemically discovered ; from the waters of the atmosphere, from whence all the rest proceed, to that of springs, rivers, and lakes.

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Of MINERAL WATERS,
strictly so called.

WERE we to attend to the various characters and analyses that have been given in books, of the different Mineral Waters, we should, at first sight, be led to imagine there was a great diversity of them ; but, on examination, the contrary appears evident.

It has been before observed, that these facts have been, in general, grossly misrepresented, and, as such, can never be the foundation of rational conclusions. In such a complicate case, therefore, to reason *a priori* will be the only certain method, and then see if the conclusions we draw from thence are compatible with such facts as we can depend upon.

1st. Spring Waters are chiefly impregnated with fossil substances ; for if ever they contain vegetable or animal matters,

it is in so small quantities as to bring them under our first division of Common Water.

2dly. As to fossil matters, they may contain, in solution, every thing that water is capable of dissolving, but no other.

But here, however, we must be cautious of assuming principles; for argillaceous and chrystalline earths have been found dissolved in water, but then the impregnation is extremely slight.

But in order to determine accurately all the possible impregnations of Waters, we shall take a view of the different forms of bodies, and see in what circumstances they are soluble in water *.

* Water is capable, likewise, of containing many bodies subtilely divided in a diffused state. This seems to be the case with many oily bodies, sulphur per se, and perhaps some earths, which are not capable of being united with water, except in this manner.

Of the Saline MINERAL WATERS.

ALL Saline Bodies we know to be soluble in water; but notwithstanding this general solubility, only the proper fossil matters, and not those of artificial production, can be admitted of. Hence the nitrous and vegetable acids are to be rejected, and the acid of sea salt, though a fossil production, yet as it is never known to be found in a separate state, so it never can, by itself, impregnate a Mineral Water. The vitriolic acid, from its almost universal distribution through the bowels of the earth, has been more generally supposed to do so. But then its attractions are so general, and so potent, as prevent its remaining long unassociated. The supposition of its being in a separate state in the bowels of the earth, proceeded

Simple Saline Bodies.

Acids.

Nitrous, muriatic, and vegetable, not contained in Mineral Waters.

Vitriolic acid.

from the notion of its giving rise to the inflammable damp in mines, and from the acidulous tartness in some waters. The first of these is a mephitic air, and the second a decomposition; for the sulphureous pyrites that contain iron, are very subject to deliquescence on exposure to the air. Hence if they are exposed in any subterraneous cavern, the vitriolic acid may be thus separated, and if this decomposition takes place not far distant from the surface, it may impregnate the spring before it be prevented by any fresh attraction.

The celebrated Dr. Lucas *, in his Dissertation on the Bath Waters, ridicules the notion of sulphur subsisting in any water, together with a superabundant acid. Had he considered the last mentioned circumstance, which so frequently happens, he would have found nothing absurd in such a supposition. In all waters impregnated with simple sulphur in a diffused state, this

* Lucas, Vol. III. p. 252.

may happen from a decomposition of the sulphur when exposed to the air.

This may be illustrated by a familiar instance. It is well known that flowers of sulphur, when kept, contract an acidulous taste, from the flying off of the phlogiston, and leaving the acid separate, though adhering to the remaining sulphur. For this reason, the London College directs them to be washed with warm water, in order to clear them of their superabundant acid.

It is well known, likewise, that sulphur is more liable to decomposition when kept in a moist, than in a dry state.

There is another fact which supports the possibility of an acid in water. The vitriolic acid, as combined with iron, is generally in its volatile state, and, when diffused in water, soon separates from the iron, and lets it fall in the form of ochre.

This has been observed in several chalybeates, where the acid has been so obvi-

ous as to change the colour of syrup of violets. But as the first circumstance is rare, and could furnish only a temporary impregnation, and as the latter is only the decomposition of a chalybeate, we cannot admit of a Mineral Water originally impregnated with the vitriolic acid.

Muriatic acid. 2dly. The Muriatic acid, or acid of sea salt, is the only other fossil acid. This is contained in fewer fossil productions than has been imagined, and is not, in like manner, subject to decomposition; therefore we exclude it.

3dly. The other two acids, as we said before, are never found native. The ingenious and learned Dr. Heberden, in his Remarks on the pump-water of London, has, however, mentioned the
Nitrous acid. nitrous acid *per se*, as the predominant impregnation in most of the waters he examined. We would willingly pay all due deference to the authority and judgment of this learned Gentleman, but, as he has not recited the methods he took
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in detecting this substance, we cannot help suspecting it to be either a mistake of this for the volatile vitriolic acid, which, in some circumstances, such as its decomposition by the fixed vitriolic acid, its exhaling a powerful odour, &c. much resembles the nitrous, or else the decomposition of some substance containing the nitrous acid used in the experiment.

We have, ourselves, made several experiments to this purpose, and have added a fixed vegetable alkaline salt to a great number of pump waters, but never could discover the smallest particle of nitre, on evaporation, which must have been the case, had the water contained the nitrous acid in substance.

Dr. Cullen likewise, the late ingenious Professor of Chemistry at Edinburgh, has made many experiments to the same purpose, but without discovery of any traces of such an impregnation. We would not, however, from any reasoning *a priori*, deny the existence of any fact supported by

the authority of so competent a judge as Dr. Heberden.

We will venture, however, to suggest a thought, which, perhaps, may reconcile both these opinions. The spring water of London, which was the subject of the Doctor's experiments, was, as he observes, "liable to many impurities from cellars, "burying-grounds, sewers, and many other offensive places, with which they undoubtedly often communicate."

Nitre we know to be the produce of putrefaction, and gained in largest quantity by a lixiviation of those earths which have had the greatest proportion of animal or vegetable substances left to putrefy in them. Is it not very probable that these springs may be impregnated in this manner? This is farther illustrated by what the Doctor says afterwards, "that a certain spring in the City never fails to yield a portion of volatile alkali in distillation, which is always the product of putrefaction, and, probably, owing to
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“ some animal substances with which it is
“ tainted in its passage under ground.”

In the nitre manufactories, the substance procured on washing the earth, is said to be a nitrous ammoniac, or the nitrous acid combined with a volatile alkali, which is changed into nitre by lixiviating it with pot-ashes. In all probability, the wells the Doctor examined contained the nitrous ammoniac likewise, which, if any fixed alkaline substance was used in making the experiment, would be decomposed, raise an effervescence, and, on evaporation, leave a perfect nitre, in the same manner as if the nitrous acid had been present in the water uncombined with any other body.

It is possible, likewise, though we never before heard it asserted, to suppose a method by which a spring might be impregnated with the nitrous acid in its separate state. Should any of the springs which contain the nitrous ammoniac, communicate with any which, from some of the circumstances before mentioned, contained the

vitriolic acid in a separate state, a decomposition might happen, by which the * nitrous acid might be disengaged from the volatile alkali, and, thus left by itself, diffused through the water. Here, however, another difficulty occurs. The vitriolic acid is always found, when native, in a volatile state, in which it will not decompose any neutral salt formed by the other acids. To this, however, we may answer, that the volatile vitriolic acid, on being largely diluted with water, is in part restored to its fixed state, which may serve to account for this appearance †.

* A great reason to lead us to believe, that the nitrous acid is never found native, is, that the smallest portion of cubic nitre was never yet found in any analysis of springs. As common salt is accumulated in so great quantities in the earth, it must often be changed into cubic nitre, were the nitrous acid present there.

† This seems true with respect to the volatile vitriolic acid *per se*, but will not hold of it when united with iron, as, in that case, it seems to be entirely dissipated on its communication with the atmosphere. This metal seems to have a power of rendering even the fixed vitriolic acid in some degree volatile, as we see in solutions of green vitriol, which, on standing exposed to the air, suffer a decomposition, owing to the acids flying off; which occasions the precipitation of the iron in a flaky ochrous form.

A still greater difficulty occurs, in accounting for the presence of the muriatic acid alone, in springs; the existence of which has the authority of the same learned Gentleman to confirm it. When combined with the fossil alkali, in form of sea salt, it is the most frequent impregnation we meet with; but we have not found any Author who has mentioned this substance uncombined, as being present in any Mineral Water.

It is possible, however, to account for this, in the same manner as the last mentioned.

Should any of the springs, which are accidentally impregnated with the volatile alkali, communicate with any that contain the vitriolic acid, either pure, or united with iron, in form of a chalybeate, a vitriolic ammoniac would be formed. Should this afterwards communicate with any source containing common salt, a double decomposition would ensue, and a Glauber's salt, and sal ammoniac, would be respectively

spectively formed in place of the others. If to this should be added, in the course of experiment, a fixed alkaline salt, a decomposition, attended with effervescence, would happen, and a common salt, or sal digestivum, would be found on vaporation; in the same manner as if the water had originally contained the pure muriatic acid.

Several Chemists have asserted the existence of sal ammoniac in springs. Dr. Cullen allows the possibility of it, but restrains it to such places as it might have been produced in by inflammation, such as adhering to the lava of volcanos, &c. That it is often produced by inflammation is an undoubted fact, but there are reasons to believe that this is not the only method by which it may be formed. Many great Chemists have been of opinion, that both nitre and common salt owe their origin to putrefaction, and that they may be respectively produced, by a slight variation in
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that process*. If this be probable of common salt, we shall find† it much more so of sal ammoniac, as one of its component parts, viz. the volatile alkali, is constantly produced, in so large proportion, in every putrefying substance. If this be true, we may suppose the sal ammoniac at once formed and communicated to the water by the means above mentioned. We beg leave to acquaint our reader, that what we have here laid down, we offer only as matter of conjecture, and that, even in our own opinion, rather a distant one.

Granting, however, that Water has been found combined with such substances, as this happens only in accidental circumstances, we cannot admit them into our list of native impregnations of Mineral Waters.

* This is, by most, attributed to the different proportions of moisture in the putrefying substance; a smaller producing nitrous ammoniac, or nitre, and a larger common ammoniac, or common salt.

† The convertibility of the fixed and volatile alkalies into one another, render this more probable.

The

Vegetable acid. The vegetable acid we know to be a purely artificial production, and never found native in the bowels of the earth.

With respect to the fixed alkalis, we may exclude the vegetable *Vegetable alkali.* one, as being entirely artificial, and which can never be accidentally washed down in sufficient quantity to impregnate a running water.

This, however, is by no means the case with the fossil alkali, since we *Fossil alkali.* know it is present in the Mineral kingdom, both in a compound state, and *per se*. The first person who observed its presence in Mineral Waters was the celebrated * Dr. Stahl. It is, however, far from being a common impregnation, nor have we seen any thing wrote satisfactorily on this subject.

* Dr. Hoffman, likewise, pursued this subject farther, and has adduced several arguments in proof of it.

The volatile alkali comes next in order. This is contained in vegetable and animal substances, especially such as approach towards putrefaction, when it is copiously generated. It is generally, however, believed, that the fossil kingdom never affords it native. Some stones, indeed, have been found, which, on being broken, or rubbed against each other, give out an odour resembling the volatile alkali, from whence the name is taken, *Lapis Suillus*.

Dr. Cullen, however, accounts for this, from some vegetable or animal substances being washed down, when in a putrid state, and these incrustations forming round them. It is, however, here, in a state of too firm concretion to be washed out by waters. When springs, in their course under ground, have access to any putrid substances, they may, by this means, be impregnated with the volatile alkali. An instance of this was given above, which is related by Dr. Heberden.

Sal

Sal ammoniac, as was before observed, may accidentally be a fossil substance, as adhering to the lava of volcanos, &c. It is found sometimes, likewise, in this country, in fissures of the earth, from whence the smoak of burning coal pits issues, and the volatile alkali might be washed out from thence by a decomposition. This case is certainly possible, but we have no fair experiments adduced in proof of it.

Henckel, indeed, in his *Bethesda Potuosa*, tells us, that he found a volatile alkali in some waters, on distillation; but in his experiments he formed a *hepar sulphuris*, and the fixed alkali, when decomposed from it, appears in a volatile form *.

Having finished what we have to say on the Impregnation of Waters with simple saline bodies, we now proceed to the compound ones.

* The convertibility of the fixed and volatile alkalies into each other, was first observed by my late worthy and ingenious friend, Dr. Butt.

Here,

Here, however, we must keep to the rule before laid down, to admit those only which are formed by the fossil neutral salts, and, of consequence, we must exclude those formed by the vegetable and volatile alkali, with the vegetable and nitrous acids. With respect to the last, indeed, the case is not so clear. Margraaf, in his Analysis of Common or Snow Water, found a portion of nitre, but then it was in so small a proportion as one grain in a hundred quarts; and as this impregnation could have no influence in practice, it would be needless to consider it.

If it be true, as some say, that nitre is directly got, by lixiviating the soil, or staple of the earth, it will be easy to conceive how a small portion of nitre might be accidentally washed down, especially after great rain, so as to give a slight impregnation to some springs. What seems to have misled many in this respect is, the resemblance in form
between

44 *Of Saline MINERAL WATERS.*

between the chryftals of nitre, and thofe of Glauber's falt and the fal cathartic. amarus.

The proper method of diftinguifhing them, would be to obferve, whether any of the chryftals, (which are in both of them hexagonal prifms) terminate at one end in a fix fided pyramid. Thefe, we may be affured, are nitre; as the chryftals of that falt, when perfect, are always in that form; whilft thofe of the other two have their extremities always truncated. Even nitre itfelf, by too hafty a chryftallization, will often put on that appearance*.

We fhall now proceed to fpeak of the moft common impregnation of Mineral Waters, and from which, indeed, fcarce
Common any are entirely free, viz *com-*
falt. *mon falt*, and this is found from

* Although the chryftals of nitre by this management may be made to put on this form, yet no art can make thofe of Glauber's falt, or fal cath. amar. refemble thofe of nitre, when regularly formed.

quantities

quantities imperceptible to the senses, to that of a saturated solution.

Though we do not allow the vitriolic acid to be found originally native in any Mineral Waters, we are ready to own, that, in a compound state, it is one of the most frequent impregnations we meet with. It is, however, found combined only with the fossil, among the alkalies, in the form of the true Glauber's salt. Though we be- *Glauber's salt.* lieve this to be a native substance, we have the utmost reason to think it not to be a common one. There are, however, some accounts of its being found native in hot climates, as about Smyrna, &c.

The Gentlemen of the French Academy, indeed, gave out, that it was plentifully found in their country; but it afterwards proved to be the sal cathartic. amarus, whose basis is magnesia, which indeed so nearly resembles the true Glauber's salt, as not to be easily detected by a bare inspection.

The

The above-mentioned are the only proper saline impregnations we know of. As for the metallic, and earthy salts, they shall be separately treated of under their respective heads. It is proper, however, to caution those, who read Authors who have wrote on this subject, that they be not misled by terms. In Dr. Short's Treatise he frequently makes mention of nitre, as an impregnation of Mineral Waters. What he means here, however, is not what we mean by nitre, but the fossil alkali, which was called nitrum, or natron, by the ancients. He probably borrowed this mistake from Dr. Lister, who likewise used that term. A late Writer on the Bath and Bristol waters, has made a discovery that one of them contains salts, and the other a neutral salt. Surely the discovery might have been carried so far as to determine of what nature these salts were; as otherwise the world is but little instructed.

Authors,

Authors, likewise, who have written on this subject, while chemistry was yet in its infancy, and, indeed, some of later date, imagined that a salt might be formed, partaking of the nature of several others. Thus we read of vitriolico nitrous salts, &c. which we now know to be mistaken notions, as salts are capable of no farther union than that of being dissolved together in the same menstruum, but always chrySTALLIZE distinct.

It must be owned, however, that native sea salt, and, perhaps, Glauber's salt, and the sal. cathartic. amarus may sometimes be found united by nature with some metallic bodies, and from some admixture of this kind, probably proceeds the various colours observed in sal. gemmæ or rock salt.

Of W A T E R S impregnated with INFLAMMABLE SUBSTANCES.

Inflammables. **T**HE only fossil inflammable substances we are acquainted with, are sulphur, and the fossil oil, which, from its different degrees of concretion from the most fluid state, to a firm solidity, is named *naphtha* and *pitcoal*. The celebrated Professor at Edinburgh is of opinion, that the two last mentioned only differed in firmness of cohesion, owing, as he thought, to the presence of some foreign body, which he, with great appearance of probability, imagined to be the vitriolic acid. It is observable, that no inflammable substance, resembling the animal and vegetable oil, are ever found below the surface of the earth; and there is some reason to believe, that the earth is capable of converting these into the form of a fossil oil. Both these substances, however, refuse a combination with water, though they may
be

be carried along with it, and so minutely diffused, as to have the appearance of a solution. We cannot, here, help observing, that the learned Dr. Lewis has carried his arguments *a priori*, in this case, to a great excess; and, from a preconceived opinion of the impossibility of their union, takes no notice of their diffusion through waters, though their presence is very often obvious to the smell and taste.

Sulphur is sometimes an ingredient in Mineral Waters, *Sulphur per se.* in a diffused state. The pipes that convey the Waters of Aix-la-Chapelle, are incrusted with it, to a considerable thickness. Sulphur, when thus diffused in water, has been thought to have acquired new properties, but, on examination, this is found to be a mistake. Many Writers on this subject, have talked much in praise of a volatile sulphur, to which they attributed great virtues. This, however, is now found not to be possible, as it proved undeniably, that there is but one kind of sulphur,

phur, and that not volatile. Probably the volatile vitriolic acid was mistaken for it. Both oil and sulphur may be combined with water, by the mediation of an alkali.

Fossil oil, united with water, by mediation of an alkali.

The fossil oil, naptha, forms a kind soap, with alkalies. This, indeed, we can perform, but by a method we can scarce expect nature to imitate. This, however, is one of the cases in which, as was observed in the first part of our work, we must not set bounds to her operations, and we certainly have accounts of such waters from accurate and good Chemists, though the instances are very few.

Hep. sulph. c. alk.

Hepar sulph. is, however, a very frequent impregnation. The learned Dr. Lewis has rather incautiously rejected this from his catalogue of impregnations of Mineral Waters, from his not being able to procure it by a chemical analysis. The reason of which is, that the hepar sulph. is decomposed, in
some

some degree, in the air, and by solution in water. The taste, however, odour, and blueish white colour, on addition of acids, are sufficient evidences of its presence.

Calcareous earths, likewise, in form of quick lime, form a kind of hepar sulph. with sulphur, *Hep. sulph. c. calce vivâ.* which is miscible with water, in like manner with that formed by an alkali, though not near so copiously. This has been sometimes suspected in Mineral Waters, but never clearly proved. Its sensible qualities, and chemical effects, differ, in several respects, from that made with an alkali. It is nearly inodorous, and the sulphureous taste, which is by many compared to that of a rotten egg, is scarce perceptible. Its chemical qualities vary much likewise; it is not precipitated from an aqueous solution by acids, as that is which is formed by an alkali.

The learned Dr. Lucas has asserted, that sulphur, and a superabundant acid, cannot subsist together in the same solution. This

is undoubtedly true of the solution of sulphur in water, by the mediation of an alkali, but does not hold with respect to that made with quick lime *. This was taken notice of in a late Treatise, intituled, *A Reply to Dr. Lucas's cursory Remarks on Dr. Sutherland's Work on the Bath Waters*. The fact, thus related, is undoubtedly true; yet the Author has no great reason to triumph over Dr. Lucas, in the manner he does, on account of his pretence to a superior degree of chemical knowledge; since the first experiments he brings in proof of his assertion, proves nothing more than his ignorance of the subject. He asserts, that water, added to quicklime, and sulphur, *calcined* together, acquired a *vitrioline* acid from the lime. The Doctor has here found a new matrix for the vitriolic acid, in which it was never before sup-

* We may judge, from hence, how dangerous it is to take these things on trust, from theory, without making the experiments to confirm them.

posed to exist in a separate state. Had he consulted so common a book as *Neumann's Chemistry*, he would have found, that the vitriolic acid, joined to quick lime, or a mild calcareous earth, forms the earthy salt called Selenites, of very sparing solution in water, and from which the vitriolic acid is scarce separable by mere force of fire. It is probable, by the Doctor's account of his experiment, unless his calcination of the sulphur was performed in a close vessel, (in which case it could be of no use,) that it would be dissipated; and what he took for a solution of sulphur, would be no more than the water impregnated with a salt resembling Selenites, composed of the vitriolic acid, in a volatile state, as separated from the sulphur and the quick lime*. The Doctor, however, seems to have derived his notion of the vi-

* If the heat was very strong, both the acid and phlogiston would be dissipated together, and nothing but a calcareous earth left behind.

triolic acid being contained in quick lime, from his observation of the generation of heat, on addition of water to quick lime, as well as to the vitriolic acid. That the same effect is produced in both these cases we readily acknowledge; but that they are owing to the same cause, we cannot so easily agree to; since alkaline salts in a caustic state, which we can scarce suppose to contain an acid, and neutral salts, when calcined, generate heat with water in greater proportion than quick lime. The true reason, however, may be explained on that universal maxim in Chemistry, that solution produces cold, and concretion heat. Quick lime, in this respect, resembles saline bodies, in requiring a certain quantity of water to be united with it, in order to its concretion. The Doctor, however, seems not to have been acquainted with this, as he asserts, soon after, that alkaline salts render water colder; which is, indeed, true of them, when united with water in a chrySTALLIZED state, as they then generate cold

cold by solution. But neutral salts have also this effect in like manner.

Perhaps some apology may be thought necessary, for having made the aforesaid observations, as we promised, in the Introduction to our Work, to keep clear of all personal reflections. We do not mean this as such, nor should we have animadverted upon this opinion of Dr. Linden's, had it not been unnecessarily introduced into his Work, in order to cast a very severe reflection on a very respectable character in our profession, some time deceased, of which he brings not the least proof, and to which neither the character of Dr. Whytt, nor the works he left behind, authorize any credit to be paid.

Of IMPREGNATIONS *of* WATERS
with METALLIC SUBSTANCES.

THE metallic impregnations of Mineral Waters are very few. Many metals are not soluble in the fossil acids, and several, that are soluble in the vitriolic acid, are only so in a boiling heat. Moreover, they are generally in a state of ore, and thus protected from their action by the sulphur.

Iron. Iron is, therefore, the most frequent impregnation we meet with, from the universality of its presence, and superior strength of attraction.

Notwithstanding the great variety of chalybeats, mentioned by some authors, we are inclined to believe, that, considered as such, they do not vary, except in the degree of saturation, as the vitriolic acid is the only native substance with which iron has hitherto been found united. Many writers have used the terms of fine and
coarse

coarse chalybeats, which have no foundation in truth, and which seem to have been drawn rather from the degree, than the nature of the impregnation. Though all the chalybeats, hitherto discovered, have been of this kind, yet we might suppose, that it might be found in waters impregnated with some of the fossil neutrals. I have seen pieces of *sal gemmæ*, which contained an admixture of iron in their chrystals, which might impregnate any spring it might meet with, in its passage through the earth. Probably it would not hold the iron in solution when dissolved in water.

Even when we are certain of the vitriolic acid and iron in a water, we can seldom get it in a chrystallized form *, as the vitriolic acid seems here to have been extracted from pyrites, which contains it in a vola-

* There are some instances of green vitriol being got, in a chrystallized form, from the waters at Hartfell, in Scotland. *Ess. Phys. and Lit.* vol. I. p. 346.

58 Of IMPREGNATIONS of WATERS

tile state ; it is therefore decomposed on exposure to the air, the iron falls down, in form of ochre, and the water loses its chalybeate taste and qualities. This gave rise to the opinion of many writers of the volatility of the vitriol itself, whereas nothing but the pure volatile acid seems to escape. This explains the appearance of a volatile spirit in them, called, absurdly, *Spiritus Mundi*. A late Writer has called the iron, thus separated from the acid, a *Mucilagium Ferri* ; but what he means by this, he himself is best able to explain. The waters that contain this volatile impregnation, do not bear transportation, except corked up as soon as taken from the spring.

Copper. Copper is frequently found in the earth, and from its being so easily corroded and dissolved by acids, and saline substances, we might imagine it to be a common impregnation of Mineral Waters. Accordingly we sometimes find it combined with water, but
not

not so common as we might expect, on account of the frequency of iron which precipitates it.

In this state it is (like iron) united with the vitriolic acid, which, on its combination with copper, seems to be, in some degree, restored to its fixed state, as no spontaneous precipitation of the metal happens in the cupreous, as does in the ferrugineous waters, on being exposed to the air. We might expect, from what has been before said of iron, to see the Mineral Waters impregnated with copper, combined with a neutral salt, as many chrystals of sal gemmæ are found tinged of a beautiful blue colour, which undoubtedly proceeds from some admixture of copper. Probably, however, the same reason subsists with regard to copper, as does to iron.

Zinck is not infrequent in the *Zinck.*
bowels of the earth, and, since it precipitates every other metal, even iron, from their solutions, it would seem remarkable that we do not meet with it oftner in Mineral Waters.

60 Of IMPREGNATIONS of WATERS.

A great Chemist is of opinion, that in its most frequent state, as the *Pseudo-Galena*, it is not acted on by acids.

Zinck, however, is sometimes found in a chrystallized state, in form of white vitriol. It is certainly a possible impregnation of Mineral Waters, though we have not seen any proofs brought of its existence as such. Probably its not having been taken much notice of by the Chemists, was not so much owing to its absence, as to their never having had it in view. Neumann, indeed, mentions some as contained in waters, but brings no particular experiments to prove* it.

* Arsenic has, of late, been said to be found in several Mineral Waters, particularly those of Chevron or Bru, in France; but we have not seen any accounts that incline us to pay any credit to it. Dr. Linden, who is so anxious for the credit of the Bath Waters, pretends to have discovered this Mineral in them; but gives no reasons that support his allegation.

WATER

W A T E R *impregnated with*
E A R T H S.

EArthy bodies, in their simple state, we know not to be soluble in water. Here, however, we must not trust too much to general principles ; for earths are undoubtedly so largely suspended in water, as to bring them under our definition of Mineral Waters. It is asserted, that chrystalline and argillaceous earths *Calcareous Earth.* have been discovered in solution in waters. These impregnations are, however, very slight ; but the calcareous earth is frequently contained in them in large quantity, and is procured not only by evaporation, but by deposition on the surface, where it frequently appears in form of stalactites, and even through the pores of some bodies, so as perfectly to petrify them. This plentiful diffusion of earth is difficult to account for, unless we suppose

62 WATER *impregnated with* EARTHS.

suppose it in form of quick lime, and that, on its acquiring its mephitic air, it is again deposited. Dr. Cullen is of opinion, that the difference of taste in these waters, is owing to the different manner in which the earths are previously deprived of their water and air; ours is done by calcination, the other by means we are ignorant of.

The saline earthy impregnations are the vitriolic acid, united with a calcareous earth, in form of Selenites, with magnesia in form of sal cath. amar. and with earth of alumn, in form of alumn. The muriatic acid is never found native, combined with an absorbent earth.

Selenites.

The first of the above-mentioned substances is the most common impregnation of springs, though very sparingly soluble in water. To this is generally owing, that quality of waters, which we call hardness, though other substances, such as the vitriolic acid, separate; the sal. cath. amarus, aluminous waters, and the common chalybeates, have all this effect.

Sal.

WATER impregnated with EARTHS. 63

Sal cath. amar. is very frequently a native substance; *Sal cath. amar.* accordingly we see it present in many springs. It is very largely soluble in water, so that we meet with many more degrees of this, than the foregoing impregnation.

The last saline earthy body that comes under our consideration, is *Alumn.* *Alumn.* of this there are great disputes among the learned, if ever it is found impregnating a Mineral Water. Neumann says, he never saw any water that yielded a perfect *Alumn.* on bare evaporation. Dr. Lewis seems to be of opinion, that the vitriolic acid is capable of changing the argillaceous earth into earth of *Alumn.* in support of which he brings a very satisfactory experiment. By this, however, it appears, that access to the air was necessary to the production of the *Alumn.* It has been moreover observed, that the aluminous pyritæ, and several other substances from which *Alumn.* is procured,

64 WATER *impregnated with* EARTHS.

cured, betray no marks of containing it, until they have been dug up for some time, and exposed to the air.

If the last mentioned circumstance was necessary to the production of alumn, we could scarce imagine it could possibly be a native fossil. We have, however, great reason to believe it to be so, as we have very good authority for asserting it to be found in Mineral Waters. Moreover, several kinds of slate have been found, which have an aluminous taste when newly dug, and from which alumn is directly elixated, without a previous exposure to the atmosphere. It is certain, however, that the communication with the air is necessary to the procuring of alumn from several bodies; and some circumstances, relative to the manner in which it is found native, make us believe this to be universally necessary to its production. It is mostly found in the interstices of the laminae, of which the stone is composed, (which are sometimes at some distance from

from each other,) but never in the body of the stone. This might give occasion to the decomposition of the pyrites*, by which means the vitriolic acid is set loose, and at liberty to unite with the aluminous earth. Should any spring interfere with any of these cavities, it might receive an impregnation of this kind. Any spring, likewise, containing the vitriolic acid in substance, running through a bed of argillaceous earth, might gain from that an aluminous impregnation.

Argillaceous earths have been said to contain a perfect alumn. That something of that kind is present in clays, that have been subjected to the action of the fire, is well known, for which reason a † late ingenious Writer has cautioned against lin-

* N. B. A circumstance of this kind was mentioned before, in order to account for the vitriolic acid alone in springs.

† Dr. Perceval, on Water.

66 WATER *impregnated with* EARTHS.

ing the insides of deep wells with brick ; and, indeed, it is probable, that the aluminous taste, discoverable in many of our springs, may be owing to this circumstance.

WATER

WATER *united with aërial* BODIES.

WE now come to the last, though not the least important Impregnation of Mineral Waters, viz. that of aërial Bodies. The presence of air in water is frequently obvious to our senses, and at all times discoverable by the experiment of the exhausted receiver. Whether the air, thus separated, be the same of *Common Air,* the air of the atmosphere, *or mephitic Air, &c.* which we breathe, or of the mephitic kind, affords room for a curious question. An eminent Chemist is of opinion, that the air which issues from water, under an exhausted receiver, is of the latter kind; and, indeed, there are very good reasons to be brought in defence of that opinion. He urges, that the air which is discharged from water under the receiver, is of the same nature with that separated by freezing, of which the following is offered as a proof: Water, in its common state, suffers

fers a large expansion from the separation of its air, in consequence of which, many bubbles are formed, which sometimes occupy a considerable space. But water, when deprived of its air by the receiver, freezes without any increase (but rather diminution) of bulk, or separation of air. In order to determine the quality of the air thus discharged, he observes, that the freezing of water bears a striking analogy to the chryftallization of neutral salts, previous to which, the separation of the air is always necessary; which we know to be of the mephitic kind, or fixed air restored to its elastic state.

On the other hand, reasons are not wanting to induce us to think the air, thus discharged from water, not to be of the fixed kind. Calcareous earths are observed to have the greatest affinity with fixed air of any known body, some metallic substances excepted; insomuch that when in their caustic state, or deprived of it, they absorb it from every other body they are united

nited with that contains it, and thus become mild and insoluble in water*. From this we should be led to conjecture, that a solution of these earths in water could contain no air of this kind. Nevertheless lime-water, placed under a receiver, shews evident marks of its containing an aërial fluid, by the bubbles it exhibits on exhausting the air. We frankly own, we are not able to reconcile these contradictory appearances, but leave them for some abler judge to determine. A certain quantity of air, of whatever kind this may be, seems necessary to be united to common water, in order to render it fit for the purposes of diet, as water that has been frozen, viz. *snow* or *ice-water*, which makes a great part of the drink of the inhabitants of

* This is proved by conveying the air from an effervescent mixture, into a vessel containing lime-water, by means of a communicating tube, which immediately causes a film on the surface, and a turbidness and precipitation through the body of the water. The precipitation is found to be a mild calcareous earth.

70 WATER united with aërial BODIES.

mountainous countries, is productive of several disorders, as glandular obstructions, &c. This was formerly attributed to the nitre contained in it; but, as we before observed, this is in exceeding small quantity, and, moreover, an innocent impregnation. Dr. Percival, however, in his ingenious Treatise on Water, has, with great probability, referred it to the separation of the air. However, notwithstanding the doubts concerning the nature of the air with which common water is united, we can have no doubt that many mineral springs are im-

Fixed air present in Mineral Waters.

pregnated with fixed air, in large quantity. This is sufficiently determined by chemical experiments. Caustic alkalies become mild, and the lime is precipitated from lime-water, by the air, arising from Mineral Waters being united with it. The effects, too, of many of them on the human body, similar to those of fermenting liquors, and which, if drank plentifully at the spring, it is said, in some, will even

even go the length of intoxication, farther evince this. Probably the antient fountain Salmacis was of this nature, and contained air of this kind in * large quantity, as the description of its effects answer nearly to those produced by fermented liquors †.

It now remains to enquire, by what means waters become thus impregnated. And here we must observe, that, on the union of all the acids with alkaline salts, or calcareous earths, in their mild state, with magnesia, or with metals, a considerable quantity of this air is discharged, and, without its extrication, they will not unite.

* ——— *Quis si faucibus hausit,
Aut furit, aut mirum patitur gravitate soporem.*

OVID.

† Plutarch, in Vita Lysandri, mentions a fountain near Haliartus, in Greece, called Cissusa, in which they say Bacchus was washed immediately after his birth, as the water is of a bright colour, tastes like wine, and very pleasant. Probably this was largely impregnated with mephitic air.

If

72 WATER *united with aërial* BODIES.

If this happens in a place to which the external air has not access, it remains united with the water with which the solvent is diluted. On exposure to the atmosphere, however, the fixed air rises in great quantity, in form of bubbles, through the body of the fluid, being powerfully attracted by the common air, which, in the opinion of many modern Chemists, serves as a menstruum to the mephitic.

This may account for the impregnation of the saline, earthy saline, and metallic springs, in this manner, as we may suppose, the union of the substances formed in the earth, which would give occasion to the separation of the fixed air, which, as long as the communication with the atmosphere was precluded, would remain quietly united with the water; but on the springs breaking out, would rise from all parts of the fluid it was united with, in consequence of its strong affinity with common air, which attracts it. To this is owing the sparkling appearance, pungent taste, smell, &c.
which

which is observed in many Mineral Waters *.

* *Neumann's Chem.* p. 176. If equal quantities of green vitriol, and the mineral alk. salt, or basis of sea salt, be dropped into a strong bottle, filled with spring water, and the mouth instantly closed, so as to leave no vacuity in the vessel, the two salts will be slowly dissolved, and subsist quietly together, as long the vessel is kept closely stopped; there being no room for the extrication of the air, which all acids expel from alkalies, on uniting with them, and, without the expulsion of which, they cannot unite with them. As soon as the bottle is opened, the salts begin to act upon one another, and the liquor exhibits the same remarkable phaenomena, as the chalybeate waters do when brought up into the open air: It sparkles or emits bubbles of air, tastes brisk and spirituous, as it is called, gives marks both of acidity and alkalescence, strikes with galls, not the black that vitriol does by itself, but a fine purple: On standing for a little time, it loses these qualities; the vitriol is destroyed; its iron falls to the bottom, in form of ochre, its acid being absorbed by the alkali. The remaining liquor, evaporated, leaves only a little cathartic salt, and a part of the alkali unneutralized; together with a portion of marine salt and different earths which the spring water contained before.

E

The

The learned Dr. Lewis has related an experiment which strongly confirms the above theory, and proves that, by a process of this kind, water may be artificially impregnated with fixed air, so as to exhibit all the appearances of the natural impregnations *.

This experiment of Dr. Lewis, however, only tends to shew, that water may be impregnated with air, by means of a mild, alkaline salt.

The same appearances, however, would happen on the addition of a mild, absorbent earth, or metallic substance, as iron, to a dilute solution of the vitriolic acid; provided the vessels were filled, and immediately closed, as in the former experiment.

Dr. Lewis has, by this experiment, ingeniously suggested a method by which a chalybeate water might be formed naturally, which should exhibit the same appearances, which we find they generally do, on

* See the foregoing page.

examination. The natural chalybeates, however, are by no means of this kind; since, if that were the case, every chalybeate water must be impregnated with Glauber's salt, if the precipitation was made by the fossil alkali, or by decomposition of common salt; or with sal cath. amarus, or selenites, if the iron were precipitated by an absorbent earth, which we find by no means to be the case; and the common chalybeates have, in general, no impregnation of the two former kinds. What proves this, moreover, is, that common salt is often found in chalybeate springs, which could not be the case, if the spring contained the vitriolic acid in a fixed state, as it would suffer a decomposition, and be changed into Glauber's salt. The vitriolic acid, however, in its volatile state, as it is found united with iron in chalybeates, is weaker in its attraction to alkalies, than the other fossil acid, the muriatic, on which account, no decomposition of the sea salt happens.

76 WATER *united with aërial* BODIES.

Notwithstanding, however, the speciousness of this theory, it labours under many objections. Were it true in its full extent, we might expect to see waters impregnated with fixed air, in proportion as they contained a greater quantity of saline matter, from which the air had been discharged, as in the formation of a neutral by an acid and an alkali.

Notwithstanding this, we see several springs that contain neutral saline matter in great abundance, and some even to a saturated solution, very lightly, if at all impregnated with fixed air. This would seem at once to overturn our theory, but perhaps even this admits of an explanation. The salts that are found thus, are, common salt, Glauber's salt, and the earthy salt called *sal cath. amar.* The first of these we have great reason to believe to be an original substance, and that its component parts never existed, native, separately in the earth, but that they were originally produced combined in the form we see them,

them, viz. common salt; and there are some reasons to induce us to think this not improbable of the sal cath. amar. and Glauber's salt.

On supposition, however, that it might be formed in the earth, by the union of an acid with an alkali, the air thus generated might be absorbed by other fossil bodies, many of which attract it, before the spring had access to it, or, at least, by some substances it might meet with in its passage to the surface. Were this true, it would account for this circumstance, as we could not expect to see springs thus impregnated with air, unless some new saline combination was directly formed by some of the means above mentioned, in the waters. It is probable, that, on this account, we see the Chalybeate Waters have, in general, more or less impregnation of air, as we have great reason to believe the solution of the iron is performed in the water by the vitriolic acid united with it, by the means above mention-

ed, previous to its meeting with the iron *.

A still greater difficulty occurs ; the foregoing method might serve to account for the union of fixed air with Mineral Waters impregnated with truly saline, earthy saline, or metallic bodies, but will not account for its existence in those waters, many of which we see contain it in large proportion, which have scarce any admixture of these substances, or, indeed, any discoverable impregnation.

It is undoubtedly found in many springs where we cannot account from its presence, by any reasoning drawn from any analysis of the water. So far, however, we may venture to suggest, that as this substance is found frequently native, in subterraneous caverns, it is probable the springs thus impregnated, passed through some of these, where they were united

* See the chapter on Impregnations with Metallic Substances.

together,

together, by means we are ignorant of*.

From the aforesaid review of the Impregnations of Mineral Waters, we find that they all may be divided into

Those im- pregnated with saline bodies.	{ Simple	{ Acid	{ 1. Vitriolic acid, <i>per se.</i> <i>Quer.?</i>
		{ Alkali	{ 2. Fossil alkali, <i>per se.</i>
Inflam- mable bodies.	{ OILS.	{ Simple	{ 5. Oil fossil, <i>per se.</i>
		{ Compound	{ 6. Oil in form of soap. <i>Quer.?</i>
	{ Sulphur	{ Simple	{ 7. Sulphur, <i>per se.</i>
		{ Compound	{ 8. Hepar. Sulph. with an alkali.
		{ Compound	{ 9. Hep. Sulp. with quick lime.
Metallic bodies.	{ Simple	{ Compound with vitriolic acid	{ 10. Copper.
Earthy bodies.	{ Simple	{ Compound	{ 11. Iron.
Aërial bodies.	{ - - -	{ - - -	{ 12. Zinck, dubious.
	{ - - -	{ - - -	{ 13. All earths diffu- fed.
	{ - - -	{ - - -	{ 14. Selenites.
	{ - - -	{ - - -	{ 15. Magnesia Glau- ber's salt.
	{ - - -	{ - - -	{ 16. Alumn.
	{ - - -	{ - - -	{ 17. Common air, dubious.
	{ - - -	{ - - -	{ 18. Mephitic air.

* The ingenious Mr. Cavendish has invented a machine by which water may be mechanically im-
pregnated with fixed air.

Besides the differences that arise from Impregnations, we make a division of Mineral Waters, from their difference of temperature, into the *acidulæ* and *thermæ*.

The last have been the subject of much enquiry among the Philosophers, and are still very indifferently accounted for. Naturalists finding that the pyrites, on being moistened with water, acquired a considerable degree of heat, have been willing, from this admixture, to account for both the impregnation and heat together.

Sulphur and iron filings generate a heat still more considerable, and to this cause they would attribute earthquakes and volcanoes. But there are many objections that will destroy or supersede the first theory; for we have accounts of *thermæ* without any degree of impregnation. But even supposing the heat to be communicated to a neighbouring stream that is unimpregnated, we cannot imagine that such a cause should act with such uninterrupted uni-

uniformity *, for such a length of time as these seem to do, since even *Ætna* and *Vesuvius* have long intervals of seeming quietude. For these reasons, a celebrated Professor at *Edinburgh* seems to think, that they owe their origin to a different cause, viz. to an internal subterraneous heat and fire, so much spoken of by Philosophers. This circumstance, he thinks, favours that opinion ; and, could its existence be absolutely proved, we might then account for the production of many fossils, which we perceive to be strongly marked with evidences of such a forming cause.

* As far as we are able to judge, there seems to be great reason to think, that the Bath Waters have not varied the most minute degree in their heat, since its first rise.

P A R T II.

HAVING thus determined the nature and qualities of the several substances contained in Mineral Waters, we shall now give a short sketch of the most approved means to be used for discovering these impregnations.

And here we do not propose to give an account of the effects of every experiment used on these occasions, with each of the impregnations; but to select such only, as may most effectually serve to discover their contents.

We shall take these in the order they are presented in the foregoing table.

The first of these that occurs is,

I. *The*

I. *The vitriolic Acid per se.*

WATERS of this kind are sometimes so strongly impregnated, as to be discoverable to the taste by their acidulous tartness. They change the colour of the vegetable blues to red, effervesce with all the alkaline salts, or calcareous earths, in their mild state, and with magnesia, and on evaporation leave a neutral, or earthy salt, according to the substance with which they were combined.

They precipitate all solutions made in alkalines, curdle soap, or render a solution of it in vinous spirits milky. A solution of sulphur in water, made by means of alkalies, is precipitated, and rendered milky by these waters, and emits at the same time a strong foetor.

Dr. Lewis says, they do the same by those made with lime water. We have repeatedly made this experiment, but find it otherwise.

They produce a slight milky cloudiness, with the solutions of silver, lead, and mercury, in the nitrous acid; and with lime water, cause a precipitation in form of selenites. Such are the general characters of these waters. Many of them, however, are not peculiar. Waters containing selenites, and alumn, effervesce with alkaline salts; and the latter shews the same effect on the vegetable juices.

In order to supply this defect, the learned Dr. Lewis recommends to distil the water whilst fresh, and then examine, if what comes over in distillation, has this effect on the vegetable blues. He alledges, that if this be the case, we may be assured of the presence of an acid unneutralized, as the neutral, or earthy salts, which produce this effect, do not rise in distillation. This theory of the Doctor's is very ingenious, and we wish we could pay an entire credit to it, as it would afford us an easy method of discovering the presence of this substance in waters.

We

We will venture, however, to suggest a circumstance, which makes us doubt if this be so clear a test as the Doctor seems to imagine. The ingenious Dr. Percival, in his *Essay on Water*, has demonstrated, that the vitriolic acid, when the salt containing it is in a state of solution in water, as in this case might often happen with so common an impregnation as selenites, is separable by a boiling heat; and that by this means the hardest waters, that owe this quality to that substance, might be rendered soft. It is probable, therefore, that this would happen in distillation, and the vitriolic acid be thus * forced over into the receiver, and impregnate the distilled liquor, in sufficient quantity to produce this effect on the vegetable blues, although

* This opinion is confirmed, by the appearances observed on the distillation of sea water, where a small quantity of the vitriolic acid, (which is always present in it,) comes over into the receiver, unless a quantity of fixed alk. or calc. earth be added to it, previous to its being committed to distillation.

it had never existed originally in a separate state in the spring. It is doubtful, if the vitriolic acid does not arise in a volatile form from felenites, which would render this still more probable.

We offer this, however, only as matter of conjecture; and, possibly, the circumstances may not be exactly similar, as a communication with the air may be necessary for the separation of the vitriolic acid from the felenites, which, from the construction of the vessels used in distillation, could not happen.

We will venture, however, to give some of the more certain signs by which the presence of this substance may be determined.

First, To observe if the effervescence caused on the addition of mild alkaline, or earthy substances, and especially the change of vegetable blues to red, does not cease to be produced on the Waters standing some time exposed to the air.

Secondly,

Secondly, To observe if any precipitation happens on addition of a fixed alkaline substance. The first of these is a pretty certain mark of the presence of an acid unneutralized, as the vitriolic acid, when in its separate state in Mineral Waters, is always in its volatile form. Were these effects produced by alum, or any other neutral or earthy salt dissolved in the Waters, they would be more permanent in them. If no precipitation happens on addition of a mild alkali, but an effervescence ensues, without any change of colour, we may take it for granted, from these two circumstances, that an acid is present in its separate state; as, were it united with an earth, or metal, some precipitation, or change of colour, would happen on addition of the alkali *.

* If the fixed vegetable alkali is used, care should be taken not to make the experiment with too large a quantity, as the salt formed by it, and the vitriolic acid, is very sparingly soluble in water, which might give the appearance of a precipitation.

II. *The fossil Alkali.*

WATERS containing the fossil alkali effervesce with all the acids, and form thus neutral salts, according to the different acids added to them, change the vegetable blues to green, and precipitate the solutions of calcareous earths, or magnesia, in any of the acids, and of the ammoniacal salts and alum in water. They render milky the solutions of silver, lead, and mercury in the nitrous acid, and precipitate the iron from the vitriolic and nitrous, in form of a yellow ochre. Dr. Lewis recommends, as the most certain mark of this substance, to observe if the water containing it effervesces with the muriatic or vegetable acids. This is certainly a good criterion with respect to those saline bodies into whose composition the vitriolic acid enters, as these would not be decomposed by addition of the muriatic or vegetable acids, but will not hold universally, as some waters, containing calcareous earths,
separate

separate in a diffused state, would exhibit the same appearance, although they contain no alkali. Perhaps the best method would be to examine the residuum left by such waters on evaporation, and the neutrals formed by it with the several acids. These might be distinguished from those formed by calcareous earths, aluminous earth, and magnesia; from the first, by their easier solution in water; from aluminous, by its larger solubility, and not possessing the styptic taste of the earth of alumn; and from all by no precipitation happening on addition of fixed alkaline salts to the solution; which would be the case with absorbent earths.

* A precipitation is occasioned in waters of this kind on addition of a solution of

* Dr. Lewis has asserted, that solutions of calcareous earths in water, lime water, for instance, decomposes neutral salts formed by an acid and alkali, e. g. Glauber's salt. I have repeated this experiment, but always found the contrary effect; as the alkali, added to an earthy salt, produced a decomposition,
but

chalk, or magnesia in the nitrous or muriatic acids. This circumstance, joined to that mentioned by Lewis, afford a reasonable presumption of the presence of an alkali, as the calcareous earth before-mentioned would cause no precipitation.

III. *Glauber's Salt.*

Compound saline substances. WATERS, containing Glauber's salt in large proportion, are easily distinguished from those that possess other impregnations, by the bitterish saline taste that accompanies them. It is, however, sometimes present in too small a proportion to be obvious to the taste. On evaporation, however, it is

but an earth, added to a neutral, produced no change. Glauber's salt, or vitriolic tartar, cannot be decomposed by any simple substance, but only by a double elective attraction, as in the case of solution of silver in the nitrous acid, and of earths in the nitrous, or muriatic.

The Dr. himself, in another part of his Work, has confirmed what is here laid down. Vide Neuman's Chemistry, p. 252.

discover-

discoverable by its chryftals, which are large and well formed, of an hexagonal prismatic form, when perfect, and truncated at both ends. They are of very easy solubility in water, and calcine in a dry air. On evaporation, however, it manifests itself to the taste, though, when largely diluted, it was not perceptible. These waters cause no change on the colour of vegetable blues, and afford no precipitation on addition of alkaline, or acid substances, in which they differ from those waters impregnated with sal cath. amarus*; which shews a precipitation on addition of an alkali, though in other respects, as taste, shape of chryftals, and easy solubility, it much resembles this. Solutions of lead and silver, in the nitrous acid, are precipitated in form of a yellowish white cloud; and that of mercury, in the same acid, in an orange-coloured one.

* The Author of the Pharm. Medici has laid it down as a distinction between these substances, that the Glauber's salt melts easily in the fire, whereas the other can scarce be fused by the most extreme heat.

IV. *Common Salt.*

THE brackish taste of many waters frequently discovers the presence of this substance. It is indeed present native in most springs, though not in quantity sufficient to be thus detected. It differs from the former by its not having the bitter taste, which accompanies the Glauber's salt, and sal cath. amar. The surest test of it, however, is, to examine the shape of the chrystals yielded on evaporation: These are always cubical, which distinguishes them from all other native substances found in Mineral Waters, as none of them assume that form on chrySTALLIZATION. It is not affected by alkaline substances; but on addition of the nitrous, or vitriolic acids, a decomposition takes place, and the salt loses its native taste and qualities, and assumes those of Glauber's salt, or cubic nitre. It precipitates the solutions of silver, lead, and mercury, (as above,) the most suddenly and largely
of

of any substance, in form of a white cloud, which soon falls to the bottom, and may be collected by itself, and proves to be the muriatic acid of the sea salt, separated from its alkaline basis, and united with the silver. It does not affect the colour of vegetable blues.

V. OILS *per se.*

THESE come next in order, and are easily distinguished *Inflammables.* by the taste and smell of the waters that contain them; which are both very acrid, and peculiar to this substance only. When in this state, they are distinguishable to the eye, as not being mixed with the water, but floating on its surface. They are generally, when thus found, of a brownish colour, and thick consistence, when it is called Petroleum, though sometimes it appears clear and colourless, when it is termed Naptha. Those wells are of this kind that take fire on application of a burning body to their surface.

VI. Oils

VI. *Oils mixed with Water in Form of Soap.*

THESE possess the same qualities with the above-mentioned, except that here the fossil oil is more intimately united with the water by mediation of an alkali. It is discovered by addition of acids, which immediately separate the oil, and leave the water clear.

VII. *Sulphur per se.*

THIS is discoverable by the taste and smell of the waters that contain it; by examination of the precipitate it lets fall on standing; which sometimes, as at Aix la Chapelle, lines the pipes that convey it. This, if sulphur, may be easily distinguished by its taste, smell, and inflammability; by the waters striking a black colour with sacch. Saturn. and solutions of lead in the nitrous acid; by their sudden tarnishing of silver; by the foetid smell, resembling
a rot-

a rotten egg, or scowering of a foul gun-barrel; on addition of alkalies; by the taste attending this addition; all which circumstances point out this substance very clearly.

VIII. *Hepar Sulph. with an Alkali.*

THE taste and smell of these waters are so remarkable, as scarce to leave any room to doubt the impregnation when they are present. They resemble, as was said before, a rotten egg, or scowering of a gun-barrel: In the latter of these, this substance is always generated on the inflammation of the gunpowder, the acid of the nitre being dissipated, and the vitriolic acid of the sulphur, joined to the phlogiston acquired from the charcoal, uniting with its alkaline basis, and forming this substance. Waters, impregnated thus, strike a black colour with solution of lead in the nitrous acid; and with a solution of sacch. Saturn. in water; from whence the sympathetic ink is derived. They tarnish
silver

96 HEPAR SULPH. *with Quick-Lime.*

silver suddenly and deeply ; become milky, and emit a strong fœtor on addition of acids ; by which they differ from the last mentioned, as the sulphur, being there in a diffused state, is not affected by acids. The former too is not distinguished by the taste and odour above-mentioned, which is peculiar to this.

It differs likewise, that this, though in part decomposed by exposure to the air, and, as Dr. Cullen thinks, by solution in water, yet retains its qualities in a great degree, when kept from the air, a considerable time ; whereas the other soon suffers a precipitation of all its contents of this kind.

IX. *Hepar Sulph. with Quick-Lime.*

THIS, though nearly allied to the former, exhibits very different appearances on experiment. It is not affected by addition of acids like the other, is altogether inodorous, and in taste, though disagreeable in a strong solution, yet, when largely diluted,

diluted, is not unpalatable, having nothing of that peculiar smell and taste resembling a putrid egg, or scowring of a gun, which so eminently distinguishes the other. It is decomposed by exposure to the air, and solution in water, as the hepar sulph. with alkali is, and on standing, even shut from the air, suffers a precipitation. It strikes no black colour with solution of lead in the nitrous acid, or of sacch. saturni in water, and scarce even precipitates them, or the solution of silver. It is precipitated by all the alkalies, both fixed and volatile, which the former is not. It has no effect in tarnishing silver.

X. Copper.

WATERS of this sort are *Metallic Impregnations*. sometimes obvious to the taste, which is, indeed, able to discover a very slight impregnation of this kind. Thus we see waters, that have stood in copper or brass vessels, gain what is called a brassy taste, though the quantity dissolved can scarce be measured. The most

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certain

certain test, however, of the presence of this metal, is, the addition of the caustic volatile alkali, as *sp. sal. amm. cum calce vivâ*. This, if the smallest particle of copper be dissolved, causes the whole of the fluid to assume a beautiful blue colour. Iron also precipitates this metal; on addition, therefore, of a plate of iron, to any waters containing copper in solution, it will soon be covered with a crust of this metal; and if it be laid in the current of the spring, will, in time, be entirely changed into it. This has given room for some, who did not understand the nature of precipitation, to imagine that the iron was really transmuted into copper; whereas no more happens than the simple precipitation of the copper, occasioned by the vitriolic acid, that held it dissolved, having a greater affinity with iron than the copper. A proportionable quantity of iron is, therefore, dissolved in place of the copper precipitated, which always happens on the surface of the precipitant, so that, in time, the whole is dissolved,

ved, and a portion of copper substituted in its place. It is observable of metals, that they always precipitate one another in their metallic form. If waters contain copper in considerable quantity, it may be discovered by chryftallization.

XI. *Iron.*

CHALYBEATE Waters are generally discoverable to the taste by their peculiar astringency. Where the quantity dissolved is very small, this, however, is not perceptible. Springs of this kind are easily distinguished by the ochrous sediment which is constantly precipitating from them, and which gives a yellow colour to all the substances exposed to their current. The principal and best known test of them, however, is, the black colour they strike with the vegetable astringents, and the purple one when an alkaline salt, or lime-water, is added to the astringent. Dr. Percival has asserted, that the ferruginous Waters will not strike a black, or purple, with many of

the vegetable astringents, without the addition of lime-water, and has, indeed, brought several experiments in proof of what he has alledged. The addition, however, of these substances, makes this experiment tolerably satisfactory, and enables us to discover a very minute portion of iron in the water. Some of the mineral astringents, as alumn, likewise precipitate this metal, in form of a reddish, yellow, ochrous sediment, which, on addition of an inflammable body, and a small degree of heat, may, like the foregoing precipitation, be again reduced into iron.

Of the metallic kind, Zinc is the only one that precipitates iron, which it does in form of a brownish powder.

Care must be taken to make these experiments with the waters when fresh from the spring, as on standing they lose these qualities.

XII. *Zinc.*

THIS substance has hitherto been so little suspected to be present in Mineral Waters,

ters, that we have had very few experiments made on the appearances it assumes on addition of other bodies. It is always found in Mineral Waters dissolved by the vitriolic acid, in form of white vitriol. It may be easily discovered on chrySTALLIZATION, by its taste, which is nauseous, sweetish, and styptic, and, by the form and colour of its chrySTALS, which are pyramidal parallelopipeds, and sometimes transparent, though generally of a dusky, yellowish hue, from the ochre of iron they contain in the state we find them.

XIII. *Earths in their native Form united with Water.*

THE calcareous earth is the only one we find united with water in its native state, and in sufficient quantity to bring it under our definition of Mineral Waters, and it is doubtful if even this be not in a state of solution in form of quicklime. Waters of this kind

Earthy Impregnations.

are not discoverable by the common tests of diffused bodies, (viz. their refusing to pass the filtre,) as these may be filtered without the least separation of their contents. Earths, thus united with water, are precipitated in large proportion by any body containing fixed air in large quantity, as mild alkaline salts, &c. and scarce at all by caustic alkali. These Waters are observed to deposit their contents on the surface of, and even to pervade the substance of, several bodies over which they run, so as perfectly to petrify them. They likewise let fall a large sediment on boiling, and it is probable, that the incrustation of many of our tea-kettles may be owing to this, though that may be produced also by the decomposition of selenites. These are distinguished from those impregnated with the following substance, in that they lather well with soap, and let fall a sediment, neither of which is the case with the selenitic waters.

XIV. *Selenites.*

THIS, as we before observed, is a very frequent impregnation. It is discovered by the refusal of these waters to unite with soap, and by their throwing down a large earthy precipitate, on addition of a mild or caustic alkaline salt. When the former is used, it is attended with effervescence. On evaporation likewise it is distinguishable by the form in which it chrySTALLIZES, being in thin laminæ, which form a pellicle on the surface of the liquor; by the taste of the salts, and water containing them after a pellicle is formed, which is lightly saline and austere. We should, however, be cautious not to mistake the waters impregnated thus, for those containing calcareous earths in substance, as they leave nearly the same residuum on boiling, by the decomposition of the selenites. The method of distinguishing them is given above.

XV. *Spurious Glauber's Salt.*

THIS is not liable to be confounded with any other substance, except the true Glauber's salt. The method of distinguishing them is given above, in our account of that substance.

XVI. *Alumn.*

WATERS containing alumn discover themselves on evaporation, by their austere astringency. * They change vegetable blues red, and coagulate milk.

The taste of felenites, though rather austere, is very distinguishable from alumn

* Dr. Percival, in his *Essay on Water*, has blamed Dr. Lewis for saying, that alumn changes vegetable blues red. He himself made the experiment with only one native vegetable juice, viz. that of radishes, which answered to Dr. Lewis's assertion. He alleges, that the syrup of violets was changed green by it. The common syrup of violets is much sophisticated, and the generality of what we have seen has been scarce altered by acids or alkalies, but always turned

by its inferiority in strength, as the former is very sparingly soluble in water. We have, however, a more certain method of discovering the presence of alumn, which is, to evaporate the water until it becomes perceptibly saline, when, if we add a few drops of lix. tart. or any other fixed alkaline salt, the earth of alumn will be precipitated, not as other earths are, (in a powdery form,) but in flocculi. If but a small quantity of alkali is used, these will be redissolved, which arises from the nature of alumn, which is the only salt we know that has a superabundant portion of acid adhering to it, which redissolves the earth of alumn precipitated by the alkali. If too much alkali is used, the superabundant acid will be saturated, and the earth not re-

turned green on dilution with water. Probably its blue colour was not owing to any vegetable substance. We have repeated the experiment with fresh violets, which were always changed to red by alumn. The proof here offered, of alumn's containing a superabundant acid, strongly confirms the probability of this.

dissolved. Dr. Lewis recommends to us to examine the precipitates of waters, thrown down by addition of alkali, with vitriolic acid. This, if the water contained alumn, will unite with the earth thus precipitated, into a highly astringent salt; if magnesia, into a saline bitter one; and if a calcareous earth, into one lightly saline and astringent, and scarcely soluble in water.

XVII. *Air.*

*Aërial Im-
pregnations.*

THE presence of aërial bodies in water, has been mentioned in the former part of our Work, where it was also remarked, that it was doubtful in what form they existed there. The experiment with lime-water, mentioned above, in our opinion proves, that common air is the substance separated by the exhausted receiver, and which is probably united, in a certain degree, with all water it has access to. Mephitic air is likewise combined, in large quantities, with many waters. This is proved by
their

their sparkling appearance, pungent taste, and smell, by their precipitation of the lime, when added to lime-water, when fresh; which effects are all lost, on their standing exposed to the air. These Waters, likewise, are sometimes discoverable by their effects on the human body, as being, if drank in large quantity, heating, and even inebriating as fermented liquors.

The air arising from these Waters, when conveyed by a bended tube on the surface of lime-water, will render it turbid, and cause a film on its surface, owing to the separation of the lime from the water.

It now remains to make some application of these rules to our experiments on the Bath Waters.

N. B. The ensuing Experiments are all made with the King's Bath Water.

P A R T III.

EXPERIMENTS on the BATH WATERS.

Sensible qualities. **B**EFORE we enter upon our chemical experiments, we shall premise a few words concerning the sensible qualities of these waters, and, *External appearance.* first, of their external appearance.

The Bath water, when drawn fresh from its source, appears quite colourless, and pellucid. Notwithstanding this, as Dr. Lucas has remarked, that some minute white moleculæ may be observed on a closer examination. It sparkles in the glass like the Spa water, occasioned by the air bubbles rising through the body of it, and flying off. On standing, it is said to abate of its pellucidity, and becomes of a
whey

whely like colour, and then it deposits a light yellow ochrous sediment, observable round the sides of the Baths. If kept stopped close from the air, it does not sensibly abate of its clearness.

These waters have no peculiar smell, nor has their vapour; though we have sometimes imagined something resembling that arising from fermented liquors, and which, without giving a sensation of any particular odour, impresses a kind of pungency of the organs of smell. This seems to be that mentioned by Dr. Lucas, which he attributes to the pyrites.

Odour.

The heat of these waters is very obvious, insomuch, that at some of the sources it is scarce tolerable to the human body. Dr. Lucas says, the water drawn at the pump of the King's Bath is, when the pump has been heated by long pumping, 119 gr. of Fahrenheit's thermometer; and to this our own, and, indeed, most other experiments, seem nearly

Touch.

nearly to agree. The water in the King's Bath, as applied to the human body, does not seem to exceed 105 or 106 degrees, by any observations we could make, occasioned by the waters being cooled, by a large exposure of its surface to the air. The heat of the water, at its source, is, however probably, much greater than any of the above-mentioned. It is sensibly hotter to the touch, and, I was once informed, by a judicious and accurate observer, who made the trial, when the source of the King's Bath was opened, that it raised the thermometer to 130 gr. of Fahrenheit's scale.

Taste. They are slightly saline, accompanied with an agreeable pungency, added to a light chalybeate taste. The two latter, however, go off entirely on the waters cooling, when it becomes much less agreeable, the saline taste is more manifest, and seems to be accompanied with another different from the taste of any saline body we are acquainted with.

What

Experiments on the BATH WATERS. III

What this probably is, shall be considered in the following part of our work.

The specific gravity of equal bulks of the Bath water and rain water, is as follows.

	oz.	dr.	gr.
King's Bath,	28	4	3
Rain water,	28	4	42

N. B. During the time this experiment was making, the water sunk near half an inch in the neck of the flask. They were weighed at the lowest mark, this is therefore their greatest specific gravity.

Chemical Analysis of the BATH WATERS.

ABOUT six gallons of the King's Bath Water was evaporated to about a quart: Before this, a considerable quantity of a whitish powdery substance, in part chrystallized, was * de-

* Dr. Sutherland, in an experiment of this kind, has denied that any pellicle was formed on evaporation, and endeavours to invalidate those experiments

posited round the edges of the vessel joining the fluid; and several pellicles were formed, which successively precipitated in a laminated form. The remaining liquor tasted evidently saline, but not so strongly as might have been imagined, as it was proved to be at least a saturated solution, from the chrySTALLIZATION of the saline matter. On evaporation to dryness, which was done with a very gentle heat, there remained about 3vij. of a powdery substance of a light dusky yellowish colour, adhering strongly to the bottom of the vessel.

*Examination
of the Resi-
duum.*

This residuum had no perceptible odour, but to the taste was apparently saline, and seemingly more so than the residuum left by those waters that contain only selenites.

ments in which this appearance is related. When the water was distilled in the manner he performed it, no pellicle would be formed, as the selenites would then chrySTALLIZE at the bottom of the vessel, as the communication with the air was obstructed.

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The greatest part of it was in a powdery form, and the remainder consisting of chrystallized substances, which, on examination with the microscope, appeared as Dr. Charleton, in the Plate prefixed to his work on this subject, has described them, to be made up of hexagonal and cubical chrystals.

Chemical Analysis of the Residuum.

EXPERIMENT I. *Vitriolic Acid to Part of the Residuum.*

About ten grains of the cubical salts were carefully separated from the rest by chrystallization. To these were added a few drops of the vitriolic acid. Immediately the smell of the spirit of salt became perceptible.

EXP. II. *Solution of Silver.*

To ʒij of distilled water, was added five drops of solution of silver in the nitrous acid, which produced no change of colour.

To

114 *Experiments on the* BATH WATERS.

To this was added one grain of the cubical salt above-mentioned. Immediately the whole assumed a white, milky appearance.

EXP. III. *Vegetable Blues.*

To 3ij of water, was added four grains of the cubical salt, carefully separated from the powdery residuum. Into this solution were put some slips of paper, rubbed with the flowers of fresh violets and polyanthus. No change of colour happened, although the taste of the solution was manifestly saline.

EXP. IV. *With the gross Residuum, Mineral and Vegetable Acids.*

To a small quantity of the gross residuum, was added a few drops of the vitriolic, nitrous, marine, and vegetable acids. It effervesced with each, and, with the vitriolic, formed a salt of little taste, but that rather austere and astringent, and of difficult solution in water. The other acids formed with it, each of them saline com-

compounds, more soluble in water, and, of consequence, more sapid.

EXP. V. *Lix. Tartar. with the Salts formed in* EXP. IV.

To each of the saline compounds thus formed, separately dissolved in water, was added a few drops of *lixiv. tart.* A white precipitation ensued *.

* EXPERIMENT I.

A few grains of the residuum we laid on a red hot iron; a crackling noise was produced, owing to the saline particles which decrepitated, but no detonation was observed, nor did any part seem disposed to fusion; no flame appeared, nor was any smell of sulphur perceived.

EXPERIMENT II.

To 3ij of the residuum, was added an equal weight of powdered charcoal, and the whole was made into a paste with oil, and put into a crucible, where it was kept half an hour. On taking it out, we found several granules of its contents vigorously attracted by the artificial magnet.

N. B. The magnet had no effect on the gross residuum *per se*.

116 *Experiments on the BATH WATERS.*

Chemical Analysis of the WATER.

EXP. VI. *Alkalies. — Caustic. — Vegetable.*

To ℥ij of Bath water, fresh from the pump, was added gutt. x. of lixiv. sapon. This caused a considerable milkiness through the body of the fluid.

EXPERIMENT VII.

To ℥ij of Bath water, that had stood corked about half an hour, was added a like quantity of lixiv. sapon. A slight milky colour, much less than in Exp. VI. was produced, which soon subsided to the bottom, in form of a white precipitation, and the fluid above, recovered its transparency.

N. B. The same experiment was tried with the water which had stood open twenty-four hours, when the effect was scarce perceivable.

EXP. VIII. *Alkali mild.*

To ℥ij of Bath water, was added gutt. x. of lixiv. tartari. This caused a copious, sudden, and flaky precipitation, much more consider--

considerable than in EXP. VI. and VII. of a reddish, white colour, extending through the body of the fluid, which, on standing, fell to the bottom, in a powdery form, and the liquor above appeared clear.

EXP. IX. *Volatile Alkali, caustic:*

To ℥ij of Bath water, was added gutt. xl of sp. sal. ammon. c. calce vivâ, which produced the smallest degree of milkiness possible, but no sensible precipitation happened on standing.

EXP. X. *Volatile Alkali, mild.*

To ℥ij of Bath water, was added gutt. xl of sp. sal. ammon. comm. This caused a milky appearance, and flaky precipitation, but not so considerable as in EXP. VIII.

EXP. XI. *Calcareous Earths in their caustic State.*

To ℥ij of Bath water, fresh pumped, was added ℥ss of lime-water, which caused a sudden flaky precipitation, which remained at the bottom in form of snow, and not in a white powder, as in EXP. VIII.

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118 *Experiments on the* BATH WATERS.

The water in the glass above the precipitated matter, became as transparent as before the addition of the lime-water.

EXPERIMENT XII.

To zij of Bath water, which had stood open some time, was added zfs of lime-water, without producing any change.

N. B. No effervescence was perceived on the addition of any of the above substances. Probably, what gave rise to the common opinion of the Bath waters effervescing with alkalies was, that this experiment was tried with alkaline salts in their solid form, and the air bubbles formed in the solution were mistaken for an effervescence.

EXPERIMENT XIII.

To each of the liquors precipitated, as in EXPERIMENTS VII, VIII, IX, X, and XI, was added spirit of vitriol, gutt. w. which restored them all to their transparency.

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EXP. XIV. *Acids.—Vitriolic.*

To ℥ij of Bath water was added gutt. v of vitriolic acid, without producing any change.

EXP. XV.—*Nitrous.*

To ℥ij of the Bath water was added gutt. v of the spirit of nitre, without producing any effect.

EXP. XVI.—*Muriatic.*

To ℥ij of Bath water was added gutt. v of spirit of salt, without producing any effect.

EXP. XVII.—*Vegetable.*

To ℥ij of the Bath water was added a tea spoonful of lemon juice, and of vinegar, without producing any effect.

EXP. XVIII. *Solution of Metals. Silver in the nitr. Acid.*

To ℥ij of the Bath water was added gutt. v of sol. of silver, which produced an appearance like equal parts of milk and water, but on adding xv gutt. more, a large precipitation ensued of white powdery
par-

particles, cohering together in masses of different sizes, and the fluid above became more transparent.

EXP. XIX. *Lead in the same.*

To ℥ij of Bath water was added thirty drops of sol. of lead, which produced an appearance like equal parts of milk and water, and gave a precipitation of small white particles, cohering together, as in EXP. XVIII, but not so copious.

EXP. XX. *Copper. In the same.*

To ℥ij of Bath water was added five drops of a sol. of copper in the nitrous acid, which gave a light blue tinge to the water, and caused a precipitation of small flaky particles adhering to the sides and bottom of the glass, but the fluid did not appear turbid*.

* To two ounces of Bath water was added fifteen drops of a sol. of mercury in the nitrous acid. This caused a slight reddish yellow precipitation, which remained in the middle of the liquor, but did not subside.

EXP. XXI. *Solution of Sacch. Sat. in Water.*

To ℥ij. of Bath water was added xxx drops of a sol. of sacch. sat. which caused a whitish cloudy precipitation of a reddish tinge, which on standing subsided.

EXP. XXII. *Solution of Galls in Water.*

To ℥ij of Bath water was added xx gutt. of a sol. of galls, which gave a slight purple tinge, but no precipitation. This effect ceased on the water's standing open a quarter of an hour.

EXPERIMENT XXIII.

To ℥ij of rain water was added gutt. i. of sol. of sal martis in water. This struck a black colour with sol. of galls, some shades darker than in Exp. XXII.

EXP. XXIV. *Sol. of Corros. Sub. in Water.*

To ℥ij of Bath water was added gutt. x of a sol. of corros. subl. This caused scarce any change at the time. On standing, however, a blueish white cloud was precipitated, and a thin film floated on the

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top.

122 *Experiments on the* BATH WATERS.

top. The intermediate liquor remained clear. On standing, a yellowish sediment precipitated.

EXP. XXV. *Sol. of white Vitriol in Water.*

To ʒij of Bath water was added gutt. x of a sol. of white vitriol. This caused no change.

EXP. XXVI. *Vegetable Blues.*

Several slips of paper, rubbed with the flowers of fresh violets and polyanthus, were immersed in the Bath water. The purple colour seemed to be heightened by the water fresh drawn. On standing, however, they acquired a greenish cast.

EXP. XXVII. *Soap.*

Two ounces of Bath water were agitated with ʒfs. of Castile soap. The fluid appeared turbid and flaky; on letting it stand, a curdled oily substance floated on the surface, and the water beneath, in a great degree, recovered its transparency.

EXPERIMENT XXVIII.

The like appearance happened, on dropping a solution of soft soap in sp. vin. rect. into the Bath water.

EXP.

EXP. XXIX. *Coagulation of Milk.*

To ℥ij of milk, boiling hot, was added ℥iv of Bath water. This immediately caused a precipitation of a light curd, but not an entire separation of the cheesy parts.

EXP. XXX. *Fixed Air.*

We conveyed the steam of Bath water, fresh pumped, by means of a syphon, into lime water. No turbidness appeared for some time; but a thin film was formed on the surface of the lime water; and, on standing some time, though secured from any communication with the outward air, it lost its transparency towards the upper part of it.

N. B. This Experiment did not succeed with water that stood, even corked up, a quarter of an hour.

EXPERIMENT XXXI.

Instead of the steam of the Bath water, we conveyed, by means of the foregoing apparatus, that which arose from mixing a sol. of salt of tart. with the vitr. acid.

This produced an evident, and immediate decomposition of the lime water ; a film swimming on the top, and a portion of the water below the film appeared turbid.

Chemical Analysis of the Sand deposited by the Bath Water.

EXP. XXXII. ACIDS. *Vitr. Acids.*

A drachm of the vitriolic acid, diluted with four times its quantity of water, was added to 3℥s of the King's Bath sand ; a sharp effervescence ensued, and many air bubbles were formed.

EXP. XXXIII. *Nitrous, muriatic, and Veget. Acids.*

The like happened on addition of the nitrous, muriatic, and vegetable acids ; with the last, however, in a very small degree.

EXPERIMENT XXXIV.

This sand, sprinkled on a red hot iron, gives a blue flame, and emits a highly acid vapour, in smell like that discharged from burning sulphur.

EXPE-

EXPERIMENT XXXV.

About 3ij of the Bath sand were put into a crucible, with an equal weight of powdered charcoal. When the matter was thoroughly heated red hot, it was poured out; several particles of it were then vigorously attracted by the magnet.

EXPERIMENT XXXVI.

To the taste the Bath sand is not in the least saline, but impresses, on being kept in the mouth some time, a strong chalybeate taste.

EXPERIMENT XXXVII.

Two ounces of water were infused on 3ij of Bath sand, in a vial, which was kept in a moderate heat about an hour. The taste of the liquor was then highly chalybeate. On addition, however, of a small quantity (about gutt. xii.) of powdered galls, little change was produced, except a slight purple tinge. By dropping in, however, gutt. iv. of lix. tart. the whole turned to a deep purple, nearly approaching to black.

EXPERIMENT XXXVIII.

About 3ij of the yellow powdery substance, that concretes round the edges of the Bath, was collected. To this was added an equal weight of powdered charcoal, and the whole was made into a paste with oil. This was put into a crucible, and kept in a red heat near half an hour. On pouring it out, a large proportion of it seemed revived into iron, the granules of which were vigorously attracted by the magnet.

EXPERIMENT XXXIX.

The like happened with the concretions formed on the basons, that hold the water glasses at the Pump-room.

Application of the Experiments.

We shall now endeavour to apply these Experiments to the discovery of the impregnation of the waters.

And here we shall take another view of the substances we have before mentioned, as possible impregnations of Mineral Waters,

Waters, in the order they are there placed; and endeavour to shew of each, what proof or probability there may be that it has, or has not, a share in the composition of the Bath Waters. The first of these that occurs is

The Vitriolic Acid per se.

THE existence of this substance in its separate state in the waters, has been much disputed. Even their sensible qualities, with respect to this impregnation, have not been clearly ascertained.

*Simple Salts.
Acids. Vitriolic Acid per se.*

Dr. Lucas * has said, that “it flies off in a subtile vapour, sensible to the organs of smell, and so as to affect the lungs of those inclined to phthysical complaints.”

We cannot say we have ever had an opportunity of observing its effects in so sensible a degree, yet we are inclined to pay

* Vol. iii. p. 277.

credit to it, as this acid is undoubtedly present in the waters in its volatile state, united with iron, which it quits as soon as it communicates with the open air. This is sufficiently proved by EXP. XXII. with solution of galls, by the ochrous incrustations deposited round the surface and sides of the Baths, and on the basons at the Pump-room, which were shewn, by EXP. XXXVIII. and XXXIX. to be reducible into iron. Arguments, however, sufficiently plausible, are not wanting to contradict the existence of an unneutralized acid in these waters, even though it was granted that their vapour were so. The vitriolic acid in these cases, it is alledged, flies off as it is disunited from the iron, and does not remain in the water in its separate state. The sensible qualities of the waters seem to favour this opinion: No acidity has been ever asserted by any person, whose writings we have examined, to be perceptible to the taste; and the trite Experiment of syrup of violets being turned green by it, has been brought as a
proof

proof of a very different impregnation, and such a one as could not possibly subsist with the other. It has, however, been urged, that the Bath water curdles milk, decomposes soap, and effervesces with alkaline salts, which are all properties belonging to acid bodies. That waters containing an acid would produce these effects we readily acknowledge, but the two former of these we shall prove, in the future part of our Work, not to be qualities peculiar to acids only, but to be producible by means of other substances, and the last we cannot help believing a mistake. By EXP. VIII. it did not appear that any effervescence was perceived, or, at least, such as was scarce perceptible, and by no means adequate to the accounts given of it by other Writers on such admixture, although the *lixiv. tartari*, which we used, is the mildest state of alkaline salts we know of, and of consequence most favourable to a discovery of this kind. Probably this mistake was produced by

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the

the cause mentioned in our Experiments*.

Notwithstanding, however, these arguments, we are inclined to believe, that the volatile vitriolic acid is present in these waters, even in its separate state, either as combined with them by the method related in our account of this substance, Part I. or in the interval between its being disunited from the iron, and its dissipation in the air. By our Experiments, the water, when fresh, appeared to heighten the colour of the vegetable purples, though afterwards on standing it seemed to exert contrary effects, and to partake, in some measure, of an alkaline nature.

Dr. Sutherland says, that the Bath Waters turn syrup of violets to a sea green colour, immediately; but he seems here to have fallen into the same mistake with many others, who have made use of syrup of violets in their experiments. The sy-

* Vide Exp. XII.

rup commonly used, is very seldom genuine, and still less frequently (which is of equal import in experiments of this nature) fresh and well made, as it loses its distinguishing colour by keeping, and acquires that brown, dusky one, we generally see it to have when genuine. When of a fine bright colour, it is generally adulterated with some substances that will not answer the tests here required.

We made several experiments with different syrups of violets, and they * all in-

* Dr. Sutherland has quoted some passages from Dr. Linden, extraordinary, indeed, in their kind, on this subject. That Gentleman has attributed the green colour, which the Bath Water is said to strike with syrup of violets, to the syrup of violets setting the acid free from the *mucilagium ferri*, and at liberty to work on the iron. Were this the case, a solution of green vitriol, where the iron is actually dissolved, would be green, which we find it not to be, even when saturated; and by our Experiment, N^o. XXIII. it appears, that one drop of a saturated solution of green vitriol, renders two ounces of distilled water more strongly chalybeate than the Bath Waters are. As to the assertion, that the quantity of alk. requisite to produce this effect, would render the water

deed, as Dr. Sutherland has related, struck a green colour, on admixture with the Bath Water; but on the same experiment being tried with rain and distilled water, the same effect was produced; and the colour seemed more owing to the dilution of the syrup, than any strictly chemical effect.

In general, the purple or blue flowers of vegetables, when fresh, or their expressed juices, answer this purpose better than when made into syrup. On the whole, if this acid be present here, it is in exceeding small quantity, and which, pro-

as *caustic* as soap lees, we beg leave to inform him, that one drop of a solution of a mild alkali, (lixiv. tart.) whose taste cannot be perceived, when diluted with lb. ss. of distilled water, will render it sufficiently alk. to produce this effect. As to what the Doctor alleges of the green colour produced by the union of acids with iron, none but the vitriolic have this effect, the nitrous and vegetable giving a solution of a dark red, and the muriatic of a yellow, gold colour. As to the *mucilagium ferri*, we really do not comprehend it, and the iron earth contained in syrup of violets, though not the Doctor's invention, we scarce expected to have been called forth to produce this effect.

bably,

bably, considered as such, can have very little power in influencing its effects as a Mineral Water; as it is likely that a quantity of it, not exceeding a drop of the concentrated vitriolic acid, is present in many pounds of the water. This is rendered farther probable by the Experiment before cited of it, when combined with iron. This proportion being so small, seems to be the reason why it exhibits none, or scarce any perceptible effervescence with alkaline bodies.

Alkalies.

Were our opinion, with re-
spect to the last mentioned *Alkalies.*
substance, ascertained, we might be well *Fossil Alkali.*
assured, that this had no share in the im-
pregnation of the waters, in its separate
state; but as we offer that only as matter
of probable conjecture, we shall examine
the reasons which might support or con-
tradict the opinion of the presence of this
substance in these Waters.

The only circumstance that gives us
any reason to think that the fossil alkali
enters

enters into their composition, is, that the vegetable blues and purples seem to acquire a greenish cast on being added to the water which has stood some time. This, however, though a quality of alkalies, is by no means a certain test of that substance. Waters impregnated with calcareous earths, in form of quicklime, will produce this effect as well as alkalies, though not, indeed, so powerfully. No marks of this salt appeared in the residuum left by evaporation, or in the salts formed by addition of the weaker acids; and the precipitation of silver, lead, and mercury from their solutions, was probably owing to another cause, which we shall mention hereafter. The iron contained in the water, in a state of solution by an acid, the curdling of soap, and the coagulation of milk, likewise afford sufficient proof that this substance, in its native form, uncombined with any other body, has no share in the composition of these celebrated waters.

Compound Salts.

It does not appear, by any *Glaub. Salt.* Experiments, that there is any reason to think that this salt is contained in the Bath Waters. Some of the crystals left on evaporation, were, indeed, of an hexagonal prismatic form, but were likewise of a slightly austere, and astringent taste, and of very difficult solution in water, qualities that ill agree with Glauber's salt. These circumstances afford sufficient evidence of what we have before laid down, as, if this salt had existed in the smallest quantity in the waters in a state of solution, it must have been thus discovered, as this salt is not so subject to decomposition, by long boiling, as many others are.

The existence of this substance in the Bath Waters has *Common Salt.* been pretty generally acknowledged, though its proportion there seems too small to have any share in their medicinal effects. Most Writers seem to have thought the cubical figure, and peculiar taste of the crystals, a sufficient evidence of this. Some Authors,

thors, perhaps, may not be so ready to allow, for granted, our decisions on the contents of waters deduced from the figure of the crystals of the salts they yield; we shall, therefore, beg the reader's patience, while we say a few words in defence of this way of reasoning. Dr. Sutherland has affirmed, "that no two salts, of the same denomination, answer the same proofs in every respect." If by this the Doctor means, that no two portions of the same salt will, on being dissolved in water, crystallize again in the same form, we can venture to assure him that they will, and appeal to experiment for the truth of it. By hasty evaporation, and too sudden application of cold, the crystals of many salts are often left imperfect; but what remains of them is always sufficient to indicate the form which they tended to assume.

The crystals of nitre and common salt, for instance, are often left imperfect, but no art can make the former crystallize into cubes, and the latter in hexagonal prisms. Dr. Hill has, indeed, said, that
common

common salt, by a certain method of crystallization; shoots into oblong parallelopipedons*. This, however, is now found to be a mistake, as they are only a number of cubes adhering together by their flat sides, which are sometimes produced when the crystallization is made to begin at the bottom of the vessel, by exclusion of the air, and introduction of any foreign body, for the crystals to form upon. Mr. Rouelle, of the French Academy, who has justly merited the applause of the learned world, for his ingenious Treatise on this subject, has made a division of those salts that crystallize at the bottom and top of their containing menstruum. This,

* Common salt often forms hollow pyramids, but this cannot confute the opinion of cubes being the proper form of its crystals. For the manner in which these are produced is this: A cube is formed on the surface of the liquor, which sinks a certain space, but has not gravity enough to carry it to the bottom. On each side of it a new cube is formed, which carries it still farther down, and then other cubes are formed on the external edges of the last, as we see them, which at length carry it down to the bottom.

however,

138 *Compound* SALTS. *Common* SALT.

however, is only true of such as are equally soluble in the cold, as well as heat.

All salts that dissolve in larger proportion in hot, than cold liquors, crystallize first where the cold is first applied. Thus, if a supersaturated solution of nitre be removed from the fire, and the surface covered, to prevent the access of cold to the top, while the bottom is placed on a cold substance, all the crystals will be formed there. It was formerly thought, likewise, that the crystals of different salts had different directions in their formation. Thus nitre was said to crystallize pointing upwards, Glauber's salt horizontally.

It is now, however, found, that the crystals of all these salts are directed from that part, where the cold is sufficient to cause them to crystallize. Thus, if on a vial, filled with a supersaturated solution of nitre, in hot water, we place a wet cloth, so cold as to cause a crystallization, all the crystals will be directed from thence, whether it be the top, bottom, or side of the vessel.

Dr.

Dr. Sutherland's arguments on this head have been before answered by Dr. Lucas. Nevertheless, Dr. Linden, in his seasonable and modest reply to Dr. Lucas's cursory remarks, has asserted boldly, "That no person in his senses now continues to believe any specific difference in the crystals of salts;" and, in support of this opinion, he urges the authority of Dr. Neuman. If by this he means Caspar Neuman, whose works Dr. Lewis has abridged, we acknowledge we have read no more of them than what that learned Gentleman has communicated, as they are mostly written in the German language. But in that part we cannot discover any reason to believe that he was of that opinion.

On the contrary, in his account of the mineral salts, he has distinguished them frequently by these marks*. Dr. Linden farther alledges, "That the *nitrum cubi-*

Vide p. 187. Of alumn. P. 198. On the distinction of Glaub. salt from nitre. P. 200. On the distinction of common salt from nitre.

cum contradicts all that can be said on this subject, as it has all and every quality of the *nitrum prismadale*, or common nitre." We really do not see the efficacy of this reasoning, except it could be proved, that the *nitrum cubicum* sometimes crystallized like common nitre, which it never does, nor does the Doctor pretend to alledge it.

The sensible qualities of these are nearly alike, and very few chemical experiments have been made to prove any difference between the cubic and common nitre. Their crystals are, however, invariably different; those of common nitre being always, when carefully crystallized, hexagonal prisms, terminating, at one end, at least in a six-sided pyramid; whereas those of cubic nitre, are, indeed, six-sided, but these sides are of a rhomboidal figure. He next says, "That the refiners are informed, by experimental facts, that large or small crystals proceed from slow, or quick boiling, during the evaporation." This circumstance is nothing at all to the purpose.

purpose. No one, who has formed a system of this kind, has drawn his arguments from the size, but figure of the crystals.

Some salts, we own, are disposed in equal circumstances to shoot into larger crystals than others, as in the case of Glauber's salt and common salt, but this is no specific distinction, as being neither constant nor ascertained in degree. The great Linnæus, in Botany and Natural History, has not drawn his distinction from the size of plants, and animals, but from some marks which are invariable, whatever be the bulk of the object: much less ought this to be here brought as a specific distinction, as in this case the slightest variation in the heat will cause a difference. In some salts, however, which are dissolved together in the same menstruum, and, of consequence, in the same circumstances with respect to heat and cold, it may, when they crystallize in nearly similar forms, sometimes afford a presumptive distinction; as in natural history the size of some plants and animals,

mals, though no essential difference, is allowed to do. Dr. Sutherland has, indeed, drawn one inference from the crystallization of salts relative to borax, extraordinary, indeed, in its kind. This has, however, been sufficiently answered, (though rather too ludicrously for the subject) by Dr. Lucas. We will venture, however, to repeat here a circumstance relative to the crystallization of salts, which Dr. Sutherland seemed unacquainted with, that all salts, which are equally soluble in hot as cold liquors, will crystallize on the naked fire, as well as in *Balneo Arenæ*.

The crystallization of common salt, by evaporation of the menstruum only, without the liquors cooling, mentioned by Dr. Lucas, is a sufficient evidence of this.

We should be glad to know what Dr. Sutherland means by simple salts, as we know of none but acid and alkaline salts; of the former of which, none of the fossile ones can be procured in a crystallized form, and only some of the vegetable
kind,

kind, as the essential salts of plants, with the salt of amber, and the acid basis of borax, called sedative salt, can be got in a crystallized state. The fossil alkali may be got in this form; but, in general, alkalis are so averse to crystallization, that an over proportion of them, joined to an acid, will often hinder the chrySTALLIZATION of the neutral salt.

Dr. Linden farther alledges, that no common salt is contained in the Bath Waters. This, however, is no more than his *ipse dixit*, and, in answer to him, we may alledge all the experiments that have been made on these Waters, and, among the rest, those of his friend Dr. Sutherland. The test he requires, of extracting $\frac{3}{4}$ vj. of salt, at least, to make experiments on, cannot, indeed, easily be complied with, since it requires a larger apparatus for evaporation than most people are masters of, as the water contains it in so small proportion. But, in our opinion, a much less quantity may serve to prove this point, as
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the figure and taste of its crystals are the most indubitable tests of it we are acquainted with.

These, joined to our Experiments I. and II. * render the presence of this substance very certain, though it is but in a very small proportion, and, probably, of little consequence in producing any effects usually attributed to the Bath Waters. The proportion could not easily be determined; it seemed, however, not to exceed five or six grains in a gallon of the water.

Inflammable Bodies.

Oils, per se. The next class of bodies that offers itself to our consideration, is that of Inflammables, among which the fossile oil, in its separate state, bears the first place. Of this, however, we have little more to say, than that the

* N. B. The vitriolic acid, and the salts containing it, precipitate the solution of silver. With the first, however, the precipitation is not near so plentiful as with common salt, and always assumes more or less of a yellow colour; whereas this was of a milky whiteness.

Bath Waters do not give the least suspicion of any impregnation of this kind, either by their sensible qualities, or chemical analysis. The taste and smell of this substance are, indeed, in general, so potent, and so distinguishable, as to leave no room for a mistake of this for any other impregnation. The immiscibility of this oil with water, likewise, affords an easy and obvious method of detecting it, even though its quantity should be too small, and its nature too pure, to admit of a discovery from its other sensible qualities *.

As this oil, however, is not, in the least degree, soluble, and only diffusible in water, however minute this may be, it must separate on standing. No such circumstance, however, has ever been observed

* The fossil oils, when pure, in form of naphtha, are thin, nearly colourless, and transparent, and have none of that strong smell and flavour they so eminently possess in the form we get them. The two last qualities are, probably, owing to the admixture of some foreign body, which Dr. Cullen thinks to be the vitriolic acid.

in the Bath Waters, nor do their smell, taste, &c. favour any opinion of this kind. We may, therefore, safely conclude, that the Bath Waters do not contain this substance in the smallest degree.

Oils in form of soap. There does not seem to be any more reason for believing that this substance is contained in the water in its compound, than in its simple state. The taste and smell of it would be equally distinguishable in this, as in the last mentioned form; and if even (for the reasons above mentioned) these might not be so observable, yet an addition of any acid substance would presently make the discovery, by the separation of the oil from the water it was united with. If our opinion, that the Bath Waters contained vitriolic acid in substance, was confirmed, it would put an end to all doubts of this kind at once; but as we offer that, not as an absolute certainty, but only as matter of great probability, we shall not lay any stress on it in point of argument. The pre-

presence, however, of this acid, united with iron in the waters, which is fully proved, affords sufficient evidence, that they contain no impregnation of this kind; as the acid, by its superior attraction of the alkali, which held the oil suspended, would cause it to separate from the water.

Moreover, if the oil were thus combined with the water in form of soap, it must diminish its transparency, (since the oil is then only in a state of minute diffusion, through the water.) As none, however, of these circumstances occur, we may rationally believe, that there are no more grounds for believing that oily substances are contained in the waters in this, than the last mentioned form.

We now come to the last im- *Sulphur,*
pregnation of this kind, viz. ful- *per se.*
phur. This question has been much agitated by many able Writers, some of whom have maintained, and others denied its existence there, with as much vehemence as they would have done, had every thing valuable belonging to them depended on this simple
H 2 question,

question. Many have maintained the opinion of sulphur's being the principal ingredient in these waters, from a lucrative view, as imagining, should this point be once disproved, it would diminish the credit of the waters, as their salutary effects were, by the generality of people, attributed to their impregnation with this substance.

Though we cannot greatly commend this motive, yet we cannot help thinking, with Dr. Lucas, that these fears have not the least foundation, since the undoubted testimonies of their good effects, which could not be influenced by this question, would much outweigh any theoretical reasoning that could be drawn from the efficacy or inefficacy of any of the ingredients in their composition.

We shall now briefly examine the arguments that may be brought in favour of, or against the opinion, of the existence of this substance in the Bath Waters.

In confirmation of its existence, it has been said, that the sand and mud taken up
from

from the bottoms of the baths, are evidently sulphureous from their smell *; that the former, laid on a red hot iron, emits a blue flame, and a suffocating vapour; that a solution of mercury is precipitated in yellow clouds by it, which is the colour it assumes when precipitated by sulphureous bodies; that corrosive sublimate is decomposed in the same manner; that a solution of silver in the nitrous acid is precipitated by them; that the mud of the waters, sublimed with arsenic in a retort, produced a true orpiment †; and that the residuum left by the waters had the same effect.

On the other hand, it has been alledged, that, granting the sand and mud taken from the bottom of the baths, contained sulphur in any proportion, yet that would not prove its existence in the waters, since we know sulphur to be insoluble in a watery menstruum; and that if it were united with the water, by means of a subtile diffusion, that this would be soon discovered by

* Sutherland's Treatise, p. 31, 32.

† Ibid. p. 35. Exp. I. and III.

the precipitations happening on the water's standing; by the incrustations of the cisterns into which it first springs, and of the pipes through which it flows, as at Aix la Chapelle; none of which circumstances are ever observed here. That the solutions of mercury, and corrosive sublimate, were changed to a yellow colour by the vitriolic acid, and that the blueish white clouds suddenly precipitating in grumes, on addition of the solution of silver, are owing to the common salt contained in the water. That the residuum, on evaporation, appears to be mostly a calcareous earth, and the remainder a saline substance, and that it gives no appearance of sulphur when laid on a red hot iron, only fuming and crackling slightly, without any sulphureous smell*, blue flame, sparkles, or detonation. That its effervescence with acids proved it not to be sulphureous, as that substance is not affected by them. That the taste of it shewed no signs of any contents of this nature, be-

* Lucas, Vol. III. p. 312.

ing only simply saline, and that but in a moderate degree ; that the colour of bright, polished silver, was not tarnished or impaired by lying in the waters a considerable length of time *.

On a review of these arguments, we are inclined to think that the latter, on the whole, are tolerably conclusive, as to this point, though they are far from being all of equal weight, or fairly stated. That which has been most relied on, viz. of the residuum left by the waters on evaporation yielding no sulphur, is the least determinate of any ; as the sulphur, if but in small proportion, would undoubtedly be dissipated in the evaporation, as sulphur is decomposed by long boiling, and plentiful dilution with water. Nevertheless, as they have no taste of this kind, nor deposit any substance on standing, that bears the least resemblance to it, and do not tarnish silver, or turn black with solution of sacch. saturni, we may safely conclude, that, in this

* Lucas, Vol. III. p. 281.

form, it makes no part of the composition of the water *.

Hep. Sulph. Sulphur, (as was before ob-
with an alk. served,) though not soluble in water, *per se*, becomes so, in a considerable degree, when combined with a caustic alkali, and even, in some degree, with a mild one.

As this combination is by no means infrequent in the bowels of the earth, and is,

* By Dr. Sutherland's experiment, of the arsenic subliming yellow, when mixed with the residuum of the waters, we should be led to imagine, that they contained sulphur. — We do not deny the fact he relates, but observe only, that even the Doctor himself seems rather diffident, as he says only "inclining to yellow;" whereas when the same experiment was tried with Bath sand, he says, "the sublimate was of a deep, orange colour." If, however, we allow Dr. Sutherland's position, that salts and sulphur are inseparable, and that the former cannot be generated without the latter, no further enquiry is necessary; as all waters, from those of the atmosphere to the deepest well, must be sulphureous, since none have been yet discovered without some admixture of a saline substance. What plentiful magazines of sulphur, then, must some of our salt springs in England be, which are nearly saturated! — This subject would afford much more opportunity for criticism, but has been already sufficiently handled by an abler pen.

indeed,

indeed, no uncommon impregnation of Mineral Waters, and as those of Bath undoubtedly meet with many substances in their passage that yield sulphur plentifully, (as was taken notice of before) many have imagined it was united to them by some means of this kind. There seems, however, to be little foundation for such a supposition, as the taste and smell of this compound are so distinguishable, even in small quantities, as to leave little doubts concerning its nature when present. No such qualities, however, have been ever observed in the Bath Waters. They are nearly inodorous, and their taste, though peculiar, by no means resembles those of that kind. Should it be urged, in answer, that the quantity contained in the Waters is too small to affect their sensible qualities, (in which case it could be but of little effect,) we may reply, that, even granting it were so, chemical experiments by no means favour an opinion of this kind. It appears by these, that silver is not tarnished, in the smallest degree, by lying in them, and the solution of sacch.

faturni precipitated, not in a dark coloured, but a yellow cloud. Acids, likewise, make no precipitation in them, which would undoubtedly be the case, did the springs contain sulphur in this form; as we find by experiment of the Harrowgate, and other Waters, that contain an hepar sulph. of this sort. We may, therefore, fairly conclude, that the Bath Waters do not contain sulphur in this form.

Hep. Sulph. c. Calcareous earths, in their
calce vivâ. caustic state, on being mixed with sulphur, render it, in some degree, soluble in a watery menstruum, as well as alkaline salts, though not in so large a proportion. From the frequency of both these substances in the earth, we should expect this to be a common impregnation; and, indeed, we believe it to be much oftener present than it is suspected to be.

An eminent Writer on the Bath Waters, has taken much pains to prove, that sulphur makes no part of their composition. His reasonings on this head seem well adapted to the subject, and prove very fully,

fully, that sulphur, in the two forms above mentioned, has no share in it. That ingenious Gentleman seems to have failed only in making his position too general, to which he seems to have been induced, by too great attachment to theoretical reasoning, as it does not appear he made any direct experiments to prove this point. It is likely he concluded, and not without great appearance of probability, that a water thus impregnated, would exhibit the same appearances with other substances, on experiment, (though, perhaps, in a less degree) as one that had the true hepar sulph. in its composition.

We are not ashamed to own, that when we first began to reason on the subject, we were misled in the same manner. Experiments, however, made with the sand which the water brings up with it, proving, very clearly, that in this were contained sulphur, and a calcareous earth, which, as was before observed, formed a compound soluble in water, inclined us to believe, that this must make a part in the

composition of those of Bath. Nevertheless, the accounts given of this substance, and its effects, by so eminent a person, and so competent a judge as Dr. Lucas*, by no means corresponding with our Experiments on the Bath Waters, staggered our opinions much on this subject. However, as the Doctor had related no experiments made with sulphur in this form, it occurred to us, that he might have overlooked it, for the reasons above mentioned. This inclined us to make the following Experiments with an artificial preparation of this kind, when, to our great surprize, they turned out totally different from what the Doctor had asserted, and our own theory had led us to suggest.

EXPERIMENT I.

Two drachms of flowers of sulphur washed, and a like quantity of fresh quick lime, were rubbed together in a glass mortar. To this compound was added, by

* Lucas on Mineral Waters, Vol. III. p. 278, section 134.

degrees, during the trituration, ℥xvi. of distilled water. This was afterwards filtered, and appeared a transparent fluid. * Its taste was pretty strong and peculiar, but no ways resembling any of the sulphureous preparations, or the Harrowgate waters.

On standing exposed to the air, it abated of its pellucidity, and deposited a whitish sediment; and this happened, in some degree, even when the air was excluded. The quantity taken up by the water seemed to diminish very little the bulk of the original compound.

EXP. 2. *Alkalies caustic.*

To ℥i. of the last mentioned preparation, joined to ℥i. of distilled water, was added gutt. x. of lixiv. saponar. This, on standing, produced a slight milky co-

* A tea spoonful of the above mixture, diluted with two ounces of distilled Water, with the addition of a few grains of common salt, formed a compound resembling the taste of the Bath Water when grown cold.

lour,

lour, with some small precipitation, as in EXP. VI. with the * Bath waters.

EXP. 3. *Alkal. mild.*

To ʒi. of the aforesaid mixture, diluted as in the last Experiment, was added gutt. x. of lixiv. tart. a sudden flaky and copious precipitation took place, precisely of the same colour as in EXP. VIII. and which, on standing, fell to the bottom, and left the fluid about clear.

EXP. 4. *Alk. volat. caustic.*

To ʒij. of the above mixture, diluted as before, was added gutt. xl. of sp. fal. ammon. c. calce vivâ, which produced the smallest degree of a milky cast, and gave no precipitation on standing.

EXP. 5. *Alk. volat. mild.*

To ʒij. of the above mixture, was added gutt. xl. of spir. fal. ammon. com-

* On this addition, the diluted mixture became nearly of the taste of the Harrowgate Spa. N. B. The mixture had the same effect on soap, and its solution, in rectified spirits, as the Bath Water.

mun. This caused a milky appearance, with a flaky precipitation, but not so considerable as in the Experiment with lixiv. tartari.

EXP. 6. *Calc. Earths deprived of their fixed Air.—Lime Water.*

To ℥ij. of the mixture, diluted as aforesaid, was added ℥ss. of lime water, which produced not the least sensible alteration in the body of the fluid.

EXP. 7. *Solution * of Metals.—Of Silver in the Nitrous Acid.*

To ℥ij. of the mixture, diluted as above, was added gutt. vi. of sol. of silver. This caused only a very slight milkiness on standing, scarce perceptible.

EXP. 8. *Of Lead in the same.*

To ℥ij. of the mixture was added gutt. vi. of sol. of lead. This caused scarce any

* To one ounce of the distilled water used here, was added gutt. vi. of sol. of silver. This induced a slight milkiness, as in Experiment 7. with the hep. sulph. c. calce vivâ.

change,

change, except a very slight milkiness, even less than in the former Experiment.

EXP. 9. *Sol. of Sacch. Sat. in Water.*

To ℥ij. of the mixture as before was added gutt. x. of the sol. of sacch. saturni. This caused a whitish cloudy precipitation, of a reddish tinge, as in EXP. XXI. with the Bath waters.

EXP. 10. *Acids. Sp. Vit. Nitri & Salis.*

To ℥ij. of the mixture as above, was added gutt. v. of the vitriolic, nitrous, and muriatic acids, without causing the least effervescence, precipitation, or change of colour.

EXP. 11. *Solut. of Corr. Subl. in Water.*

Ten drops of a saturated solution of corrosive sublimate were added to ℥ij. of the mixture as before. A blueish white cloud was immediately precipitated, and a thin film floated on the top, as in EXP. XXIV. with the Bath waters.

EXP. 12. *Of white Vit. in the same.*

To ℥ij. of the sol. of hep. sulph. c. calce vivâ, diluted as above, was added
gutt.

gutt. x. of a saturated solution of white vitriol. This caused scarce any change, except a small blueish tinge towards the bottom of the vessel. When the solution of hepar sulph. was used in less proportion, as xxx. gutts. to \bar{z} i. of distilled water, (which gave nearly the same taste as the Bath water when cold,) no change was observed.

EXP. 13. *Sol. of Merc. in Sp. of Nitre.*

To \bar{z} i. of the original preparation, diluted with \bar{z} i. of distilled water, was added gutt. xv. of sol. of merc. in the nitr. acid. This caused a slight reddish white precipitation, which remained in the middle of the liquor, but did not subside.

EXP. 14. *With the Residuum deposited on standing by the Sol. of Hep. f. c. c. viv.*

Six grains of a whitish equable residuum deposited by the sol. of hep. f. c. calce vivâ, on standing, were collected. Two grains of this were laid on a red hot iron; it fumed slightly, but gave no blue flame, sparkles, or detonation, nor emitted the
least

least sulphureous smell, though carefully observed. The residuum, on burning, changed from a white, to a light ash colour.

N. B. This Experiment was several times repeated.

EXP. 15. *With the same Acids.*

Ten grains of the above residuum were collected, and carefully dried with a very gentle heat. To this were added gutt. v. of the vitriolic, nitrous, and muriatic acids. It effervesced strongly with each of these, and with the vitriolic, formed a saline substance, which appeared from its taste, &c. to be selenites.

EXP. 16. *Vegetable Blues, with the Mixture.*

A piece of writing paper, stained with the blue leaves of violets, and another with the purple of polyanthus flowers, was immersed in a quantity of the mixture, diluted as above, and fresh made. No change of colour happened. The same Experiment was tried with it, after having stood exposed to the air some time, when
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it immediately changed them to a green colour.

EXPERIMENT 17.

Two ounces of the mixture were added to an equal quantity of the Bath water, without any observable change.

From a review of the above Experiments, it appears, that most of them correspond in effect with those made with the Bath Water; and in those where the appearances differ, we think the variation is owing to some other substances, which are known to form the impregnation of the Bath Waters besides the foregoing. In order to evince this more clearly, we propose to give a short comparative view of the effects produced by the same Experiments on the Bath Water, and our artificial preparation, and then see if these different appearances may not be explained on the foregoing principles.

EXP. VI, 2. *Alk. Caust.*

The effect of this seems nearly the same in both. The caustic alk. seems to act in each,

each, by decomposing the hep. sulph. c. calce vivâ, disengaging the lime from the sulph. and taking its place; which, however, as the caustic alk. supplies no fixed air *, still remains dissolved in the water.

EXP. VIII. 3. *Alk. mild.*

The hepar sulph. is here decomposed †, as in the foregoing Experiment, though the mild alk. is but very sparingly miscible with sulphur. A double decomposition, however, here takes place, which seems to effect their union. The quick lime at-

* Some small precipitation happened in the artificial precipitation, as well as in the Bath Water, probably owing to the alk. not being perfectly caustic, which is difficult to procure. The Bath Water exhibited a much larger precipitation when fresh, than after having stood some time, which proceeded, probably, from the quick lime, disengaged by the alk. from the sulphur, attracting the fixed air suddenly, which we have before seen to be so plentifully contained in the water, when fresh drawn, and being thus precipitated. This accounts for this circumstance not being so observable in the water that had stood some time.

† Experiments VI. 2. VIII. 3. In both these Experiments a true hep. sulph. is formed.

tracts

tracts the fixed air from the mild alk. which is thus rendered caustic, and enabled to unite with the sulphur, while the lime, thus rendered mild, and, of course, insoluble in water, falls down in form of a mild calcareous earth, and forms the copious, white precipitation, observed in the Experiment. This, however, will be better understood by the annexed scheme.



EXP. IX. 4. *Vol. Alk. caust.*

The appearances shewn on addition of this substance, seem to be the same in both *.

* It is doubtful here, if the hep. f. c. c. v. would be decomposed, as the quick lime seems to have a stronger attraction to sulphur than the vol. alk. Probably the slight precipitation (observed on standing) in both, was owing to the alk. not being perfectly caustic, which is very difficult, and, indeed, nearly impossible to procure, as it attracts fixed air from even a silver vessel, in which the evaporation is performed, when wanted in a dry form.

EXPE-

EXP. X. 5. *Vol. Alk. mild.*

* The earth is here precipitated in both, for the reasons given above, when we spoke of the fixed alkali, but not in so large proportion, as the vol. alk. is scarce ever got so mild as the fixed, and, besides, does not contain fixed air in so large proportion.

EXP. X. 6. *Calc. earths deprived of their air.—Lime water.*

The effects of this on the mixt and on the Bath Water when fresh, are totally different. With the former no perceivable effect was produced, whereas with the latter it occasioned a copious precipitation. This difference, however, may be easily explained. The Bath Waters, when fresh, are known to contain fixed air in a large quantity, which the quick lime in the water greedily attracts, and is thus rendered insoluble, and, of course, precipitated.

* The hep. f. c. c. v. seems to be here decomposed by a double elective attraction, which may be understood by the scheme laid down in the foregoing page, only substituting the volatile, in place of the fixed alkali.

Pro-

Probably the different form of the precipitation when an alk. and lime water were used, is owing to this, that in the former the lime was separated from the sulphur, in the latter, only precipitated from its simple solution in water.

What proves this more clearly is, that the precipitation is the largest, when the lime water is added to the Bath water fresh drawn, and is scarce perceivable when added to the water that has stood some hours exposed to the air *.

* It might be here alledged, that the precipitation was owing to the volatile vitriolic acid, which (as was before said) there was reason to believe the presence of in the waters, forming a kind of selenites with the lime, which, as being so sparingly soluble, would cause a precipitation. That this would equally account for the ceasing of this effect on the waters standing exposed to the air, as the volatile vitriolic acid soon evaporates. This, however, cannot be the case altogether, as the precipitate effervesced strongly with even the vegetable acids. As, however, there is reason to suspect the presence of the volatile vitriolic acid, the precipitate might be composed of both these substances; viz. a small part selenites, and the remainder a mild calcareous earth.

EXPE-

EXP. XVIII. XIX. 7, 8. *Solution of Metals—Silver, Lead, &c. in the Nitrous Acid.*

The event of the corresponding Experiments with these substances, turned out totally different, the solutions causing a large white precipitation with the Bath water, whilst they shewed scarce any effect on the other; and the small degree of precipitation which was observed, was, in all probability, owing to some saline substance, perhaps the vitriolic acid, which it is difficult to get even distilled water absolutely free from. Thus much, however, we may reasonably presume, that the hep. sulph. c. c. v. is not the substance that causes this effect. What produces that plentiful precipitation in the Bath water, is, undoubtedly, the common salt, which, as was before observed, in the smallest proportion possible, viz. of a grain to a gallon of water, will cause a milkiness and precipitation with the solution of silver or lead.

EXPE-

EXP. 13. *Sol. of Merc. Nitr. Acid.*

The difference of the effects produced on addition of this substance to the mixt, and to the Bath Water, is very observable. With the former it exhibited a slight, reddish cloud ; with the latter, a copious, white precipitation. This, however, seems owing to the same cause as the foregoing. In the former, the solution of mercury seems precipitated by the vitriolic acid, which is separated from the sulphur by the attraction of the mercury, or by the decomposition of the hepar sulph. c. c. vivâ, in some degree, by its solution in water ; which causes the precipitate to be of that reddish, yellow colour, which is the same that mercury, precipitated by the vitriolic acid, always assumes. In the latter case, the precipitation is certainly occasioned by the common salt, the muriatic acid in it having a stronger affinity with mercury than the vitriolic acid has, which causes the difference of colour in the precipitations. What confirms this is, that if a few grains of common salt be previously added to the

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mixt,

mixt, the mercury is precipitated from the solution, of a white colour.

EXP. XXVI. 11. *Sol. of Corr. Sub. in Water.*

The appearances in both cases, on addition of this substance, seem nearly the same, and, probably, would have been exactly so, could we have brought the mixt to the exact standard of proportion of impregnation with the Bath Waters.

EXP. XXV. 12. *Sol. of White Vitriol.*

No perceptible difference was observed between the mixt and the Bath Waters, on addition of this solution.

EXP. XIV, XV. 10. *Acids. — Vitriolic, nitrous, muriatic.*

The acids seem to have had no visible effect on either the mixt, or the Bath Waters.

EXP. XXVI. 16. *Vegetable Blues.*

The mixt, when fresh, seems to agree with the Bath Water, in its shewing little change at first in the colour of vegetable blues; though when kept some time it exhibited the same effect. The Bath Water, indeed,

indeed, when fresh drawn, seemed to change the vegetable blues to a little of a reddish cast, but this was probably owing to a superfluous quantity of the volatile vitriolic acid, which, as we before observed, there is great reason to suspect the presence of in these Waters.

From what has been before urged, and from the above comparison of the Experiments, we think there is the greatest reason to believe, that sulphur, in this form, makes a part in the impregnation of the Bath Waters. We own, that all the comparative Experiments do not coincide; but those which differ, we hope have been satisfactorily explained to proceed from the effect of some other substance, whose presence there we are assured of. The composition of the substance thrown up by the waters, called Bath sand, being demonstrated to be sulphur, joined to a calcareous earth, proves the possibility, if not (as forming a compound soluble in water) the necessity of such an impregnation; and the agreement of the comparative Experiments

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made

made with an artificial composition of this kind, with those made on the Bath Waters, in all the material circumstances, give, in our opinion, a rational proof of the existence of this impregnation.

Metallic Substances.

The next class of bodies that comes under our consideration, is that of Metallic Substances; the first of which, in the order they are placed in our table, is — Copper.

There does not seem to be the least reason to suspect the presence of copper in the Bath Waters. Iron immersed in them is, indeed, soon corroded; but no precipitation resembling copper is ever deposited on its surface, as is the case with all waters that contain that metal in a state of solution. The Bath Waters seem, indeed, to have very little effect on copper, as we see by the rings in the King's Bath for the bathers to hold by, which are mostly made of copper, and many of them, as appears by their dates, have continued near a century, and some of them more, and still remain

main little diminished; whilst those of iron are entirely consumed in a twentieth part of the time. The caustic volatile alkali likewise shews no signs of a cupreous impregnation, but mixes with the water without any change of colour. No signs of this metal, in any form, appeared in the residuum left on evaporating the waters. The crystals there were all colourless, and in taste and effects by no means resembled the blue vitriol. On the whole, we may rationally conclude, that this metal is not contained, in any form, in the Bath Waters.

The presence of this metal,
in these waters, has been ac-
knowledged by all the Writers on this sub-
ject. The purple tinge it strikes with so-
lution of galls, when fresh, the ochrous in-
crustations of the baths, which we shewed
by Experiment XXXVIII. were capable
of being revived into a metallic form; the
Experiments made with the residuum of
the waters on evaporation, and with the
Bath sand, put this circumstance beyond a
doubt. As to the form in which it is con-
tained

Iron.

tained in them, it is here, in our opinion, suspended, by means of the volatile vitriolic acid*. This is indicated by the purple tinge it strikes with solution of galls, and the reddish one it gives to the vegetable blues when fresh, and by the ceasing of both these effects on the water's standing, and by the spontaneous precipitation, on its exposure to the air, of the ochrous sub-

* It has been suggested to us, by a very ingenious and learned Physician, Dr. Haygarth, of Chester, that the chalybeate impregnation was owing to the fixed air contained in the waters, and not to the volatile vitriolic acid, according to a theory founded on experiments mentioned in the *Philosophical Transactions*. That this would account for the slightness of the impregnation, as the water would contain but a certain portion of the mephitic air, which was capable of dissolving a very small proportion of iron only. That this, likewise, would equally account for the precipitation of the iron, on the water's being exposed to the air. These reasons are ingenious, and worthy of our consideration; and yet we are not inclined to think them satisfactory in this case, for the following reasons.

1st. Because the sand deposited at the bottom of the baths, contains iron united with the vitriolic acid, in a form soluble in water, as is proved by pouring common or distilled water on it, which, in a few minutes, extracts a strong chalybeate tincture from it.

2dly, Be-

stance before mentioned. As to the proportion of this metal contained in the Bath Waters, it is, undoubtedly, very small. Dr. Lucas has computed it at one thirty-seventh and a half of a grain of iron in a pint of the water, and this computation seems tolerably just. This circumstance, however, as he very properly observes, is very difficult to be ascertained with any great degree of exactness. As to the notion of a volatile vitriol, that has already been sufficiently refuted in another part of our Work; and those who desire to see more on this subject, we would refer to Dr. Lucas, who has, with great learning and judgment, exposed this opinion, and proved, that what gave occasion to this notion, was no other than the flying off of the volatile vitriolic acid, which held the iron dissolved, on which the water ceased to ex-

2dly, Because the Bath Waters themselves, even when cold, are capable of acting on iron filings.

3dly, Because a solution of galls precipitates the iron from the Bath Water of the same colour as it does from a solution of green vitriol.

hibit the appearances which are commonly accounted proofs of a chalybeate impregnation. The iron, however, in this case, was so far from being volatilized, that it was precipitated.

A curious question arises on the subject of this impregnation, which we have not seen taken notice of by any other Writers, and which, we own, we are not able to resolve satisfactorily, viz. why these waters do not give stronger proofs of a chalybeate impregnation than they do? It does not appear, on their analysis, that they contain any substance that would precipitate the iron, were it contained in them in much larger quantities than it really is. Dr. Lucas says, in confirmation of the above opinion, that Bath water, poured on filings of iron, dissolved them plentifully; and it appears by our own Experiments, that even cold water extracted, in a few minutes, so strong a chalybeate impregnation from the Bath sand, as to strike a deep black with solution of galls. Nevertheless, the Bath waters, which, undoubtedly, pass through many beds of minerals containing this metal in
large

* large quantity, and that, too, in a form capable of solution in water, exhibit but a very faint impregnation of this kind. This circumstance seems difficult to account for. Perhaps it may be owing to the large proportion to, and swift passage of, the water over the pyrites, containing this metal. This, however, is not fully satisfactory, as it would hold equally strong against all the other impregnations, some of which are contained in the waters in much greater proportion than the chalybeate one. We will venture, however, to suggest a circumstance, which, though not of itself quite satisfactory, may yet throw some light on this subject. The learned Dr. Lewis gives an account of an Experiment, that has been related in the former part of our Work, in which he found, that, on addition of a fixed alkaline salt, to a solution of green vitriol, no decomposition ensued while the air was excluded; but that, on its admission, the acid

* Both these circumstances may be reasonably presumed, from the Experiments related with the Bath sand.

and alkali presently united. May not the volatile vitriolic acid, in like manner, exert but little effect on the ferruginous particles, until the communication with the air is obtained, and then its swift passage may not afford opportunity for a more plentiful impregnation *.

If this theory should be blamed, as too vague, or uncertain, we beg leave to repeat the excuse we have formerly made, which is, that we offer these things only as matters of conjecture; and this, we hope, will plead in behalf of our mentioning them.

On the whole, then, the presence of this metal in the waters is beyond a doubt, though its proportion there seems to be smaller than in any chalybeate we have examined.

* It may be alledged, that this argument might be urged, with equal force, against all chalybeates whatever. These, however, may some of them have access to the air, by some subterraneous passages, or caverns, similar to those mentioned in our account of the vitriolic acid *per se*, and its separation, by decomposition, from the pyrites, which may not be the case with the Bath Waters.

The presence of this Mineral has never been suspected here. Indeed (as has been before observed) it is a doubt if ever it forms a native impregnation of springs. However this may be, there does not seem to be the least reason for thinking it makes any part of the composition of the Bath Waters. Its sensible qualities, and the effects it produces even in very minute quantities, when dissolved by the vitriolic acid, which is the form it must exist in, if at all, by no means coincide with those usually produced by these celebrated Waters. Zinck thus dissolved, is possessed of emetic, and, at the same time, narcotic qualities; and these effects are produced by a very small proportion of it. These qualities, however, ill agree with those of the Bath Waters, and the cure of those disorders for which they are so much famed. The crystals, likewise, procured on evaporation of the Bath water, have nothing of the sweetish taste so remarkable in the white vitriol, and are likewise of more difficult solution in water. In a word, we have not

Zinck.

the least reason, either from the sensible qualities, or chemical analysis of them, to suspect that zinck enters into their composition.

In the former part of our Work, we mentioned the three impregnations above spoken of, as being all of the metallic kind, that were to be found native in Mineral Waters. Notwithstanding, however, this assertion, which we believe to be just as to native impregnations, an accidental combination with another metallic substance, and that, too, not the most innocent with respect to the human body, may sometimes take place in them, especially in those of the thermal kind.

The effects of lead on the
Lead. human body are well known :
 “ Obstinate constipations, violent colics,
 “ pains and contractions of the limbs, tremors and resolutions of the nerves, and
 “ slow wasting fevers, are the consequences
 “ of this metal taken internally, and of the
 “ fumes to which the workmen are exposed

“ posed * in the fusion of this metal, in the “ way of business;” and even the external application of cerusse has been known to produce this effect. This metal, however, is generally thought not to be soluble in the vitriolic acid, unless in a boiling heat; and this seems true with regard to the fixed; but as to the volatile, it is by no means to be depended on, as that will act on lead in an inferior degree of heat; and though its attraction to metals does not seem to be so strong, yet it dissolves them in much larger proportion than the other.

After having given the above account of the effects of this pernicious metal, we should be sorry to insinuate any suspicion of its presence in these salutary springs. Nevertheless, the cistern, which serves as a reservoir for the spring at its first rise, appears plentifully corroded on its inside, by the long furrows which are visible in every part of it. This proves the possibility of

* Lewis Mat. Med. Art. Plumbum.

such an impregnation, though, probably, its proportion there is too small, or perhaps counteracted by some other qualities of the waters, to work any obvious effects on the human body. This, however, is, by no means, a justification of the use of any thing liable to give an impregnation of this sort in the slightest degree. A portion of several metallic substances, almost too minute to be discerned, is capable of working great changes in the human frame; and among these *Lead* claims the chief place, and is perhaps the most dangerous, as it frequently works by slow, and almost imperceptible degrees, and has often completed the mischief before the person was sensible of his danger, or to what cause to attribute his malady *. The noted Colic

* Nec minus infelices qui aquam plumbo divitem bibunt, plumbeis ædes tectæ laminis, ubi pluvialis sola bibitur, in cisternis collecta, vel in plumbeis servata vasis, quod pessimum, frequentiore multo faciunt morbum: et hæc est ratio quare insolitus olim colicus dolor, grassetur nunc Amstelodami. Tegulis antea tectæ, hodie plumbo teguntur ædes, superne olim declives, nunc planæ. Volitantia sub finem autumnii folia decidua, viridarium enim crederetis urbem,

at Amsterdam was of this kind, which for a long time eluded the search of the learned with respect to its cause; and it seems probable, from some ingenious Experiments, by Dr. Baker and others, that the Devonshire Colic proceeds from the same origin.

If to this it should be objected, that we have no accounts of any such effects produced by the Bath Waters, and that, on the contrary, they have been proved to be very efficacious in the cure of these very diseases, we may reply, that the action of the water on this metal has been sufficiently proved, and that it is possible, that the unfavourable symptoms sometimes produ-

urbem, ventis in testa feruntur, macerata ibi aquâ stagnante, hanc inficiunt acore, quo solutum plumbum in cerussam abit, ad cisternam dein rapitur imbre, sic sensim inficitur aqua. Nec mirum si in aliis locis ubi deficit plumbum, arboresque defunt, minus frequentes sint colici dolores. Hinc intelligitur quare, si, cadentibus foliis, tenues nullæve sint auræ, si caute ligno tegatur plumbum, salubrior aqua fit. Fidem observata merentur, vidi malum in integras sæviisse familias, undecim in unâ domo, uno tempore decumbentes, horrendis cruciatibus convulsi, membris soluti, mutato tecto, renovatâ aquâ, convalescere.—*Tronchin de Colicâ Pictonum*, Art. X. p. 66, 7.

ced

ced on drinking them, which we know not how to account for otherwise, may be produced by some such impregnation ; as this metal, though its effects are sometimes latent, is seldom inactive. It may be, perhaps, owing to this cause, that some disorders of the spasmodic kind, as the opisthotonus, seem sometimes rather enhanced by drinking the waters, when bathing alone is of great service. This may likewise occasion the retardation, and sometimes the failure of cure, of many bowel disorders ; and the obstinate costiveness*, so much complained of on drinking the Bath Waters, which is a constant effect of that mineral, makes this conjecture not improbable. Effects, when slowly produced, and the reasons not self-evident, are often neglected, or attributed to unavoidable causes, or circumstances to which they do not belong. The noted Colic at Amsterdam had many causes assigned for it, before the true one was discovered ; and it is possible, that this quality in the Bath Waters may not be

* The waters of the hot Bath are observed rather to open than bind the body. The reservoir there is made of stone.

originally inherent in them, but perhaps owing to some accidental circumstance of this nature.

From an examination of their contents, we can discover nothing to which this effect can rationally be ascribed; and, if we reason from analogy, all the sulphureous preparations tend rather to loosen than bind the body. An eminent and ingenious writer has cautioned against the use of lead in our common pumps, as he says, that although lead may not be obviously soluble in common water, that a portion of it may be abraded, and so minutely comminuted by the working of the pump, as to be suspended in water, and thus capable of being received into the human body. If this caution was well founded, as to laying aside the use of lead in common pumps, how much stronger will it be applicable in this instance, where the pump is worked daily many hours together, and the abrasion consequent on it proportionably greater, and the very water drawn by it capable of holding it in a state of solution? If it be farther

farther alledged, that no lead appears to be found in the waters, even * by our own experiments, we may answer, that this metal is sufficiently proved to be acted on by the effect beforementioned to be produced on the reservoir; and though the proportion contained in any quantity of water capable of coming under our examination, might elude a discovery by a chemical analysis, yet its effects on the human body might be still possibly exerted. This was the case at Amsterdam before quoted, where, though the disorder was undoubtedly owing to this cause, and its proportion vastly larger than it could be in this instance, it was still so minute, as to be scarce discoverable by a chemical examination.

On the whole, when we consider the nature of those diseases which are generally recommended to these waters for relief,

* It is not improbable, that the decomposition of the tinctura fulph. volat. mentioned by Dr. Lucas, which we find, on repetition of the same experiment, to be true, may be owing to some degree of an impregnation of this kind.

which

which are * many of them of the same kind with those occasioned by this pernicious mineral, and some actually produced by it, we shall then see the peculiar propriety of avoiding any possibility of an impregnation of this nature. We would, therefore, humbly, though earnestly, recommend to those, who are the guardians of these antient and justly celebrated fountains, to substitute a reservoir of marble, or what, perhaps, may be full as proper, of grit stone, in place of the leaden one now used; and wooden, or, what may serve the purpose still better, cast iron pipes, for the supply of the pump.

We mentioned, in the former part of our Work, that *Earthy Substances, simple.* there was but one kind of earth that was ever found, in its simple state, native in springs, in sufficient quantity to bring them

* Many minute circumstances, which perhaps might have scarce any perceptible effect on a person in health, might be of the worst consequence to those who are already predisposed to disorders of this kind.

under

under our definition of Mineral Waters;
Calcareous and this is the calcareous.
Earth. Whether this enters into the composition of the Bath Waters, uncombined with any other substance, is a curious question. The copious precipitation of a calcareous earth, consequent on the addition of a mild alkaline salt, would lead us to imagine this to be case; as this always happens on their being added to lime water.

Though we do not deny that a small proportion of calcareous earth, in form of lime, may be found in the Bath Water that has stood some time, which is rendered still more likely, by the greenish tinge the water gives to the vegetable blues in these circumstances; yet we have no reason to think any such substance is united with them when fresh, as they then seem to give proofs rather of an acid impregnation*. The signs they seem to give of an impregnation of an alk.

* Vide Experiment XXVI. where it is said to change the vegetable blues to a reddish tinge.

nature,

nature, may be owing to the decomposition of the hep. sulph. c. calce vivâ contained in the water, caused by the flying off of part of the acid, and leaving a superfluous quantity of the calcareous earth in form of quick lime united with the water. By our Experiments it appears, that the hep. sulph. c. calce vivâ answered all the tests above mentioned, which are commonly accounted proofs of the presence of a calcareous earth. The manner that this comes to pass has been above explained, when we treated of that substance. What proves, however, that calcareous earths are not found native in these waters, is, that no precipitation happens on addition of a few drops of the vitriolic acid, which would undoubtedly be the case, did the water contain the earth in this form, as they both would then be precipitated together in form of selenites. The plentiful impregnation of these waters with fixed air, likewise seems to confirm this opinion, as this would undoubtedly unite with the calcareous earth, and, by restoring it to a
mild

190 *Earthy Substances — Compound, Selenites.*
mild state, destroy its solubility in water*.

We may, therefore, safely conclude, that calcareous earth is not found native and uncombined with any other substance in the Bath Water.

Though we cannot allow that calcareous earths *per se* have any share in the composition of these waters, we are ready to own

<i>Earthy substances.</i>	that, in their compound state,
<i>Compound.</i>	they form one of its principal
	impregnations. Combined with
<i>Selenites.</i>	acid, in form of selenites, they
are undoubtedly contained in the wa-	

* The calcareous earth, left on evaporation of the Bath Waters, might countenance the opinion of its presence there in a separate state. This, however, may happen, and is probably occasioned by the decomposition of the hep. sulph. c. calce vivâ, which, on standing exposed to the air, and more especially by strong boiling, suffers a decomposition, and of consequence, separation of its parts: The vol. vitric acid and phlogiston being dissipated, and the calcareous earth precipitated in a mild state. Selenites, too, which is largely contained in these waters, undergoes in the same circumstances a similar decomposition, and may in part occasion this appearance.

ters,

ters, as appears plainly from the crystals left on evaporation, which were of * an hexagonal prismatic form, of small size, nearly insipid, and scarce perceptibly soluble in water. To this impregnation the curdling of soap may possibly be owing, though that may be produced by the hepar. sulph. cum calce vivâ †. On the whole, the foregoing Experiments sufficiently prove the presence of this substance, though it

* Selenites is described by many authors(*), who have wrote on the crystals of salts, as crystallizing on the surface of its menstruum in these laminæ(*). This, however, is only a mistake, since it only happens when the evaporation is carried so far as to form a pellicle on the surface. In that case it crystallizes in a seemingly laminated form; but on microscopical examination even these appear to be composed of hexagonal prismatic crystals, though small and irregularly formed, occasioned by their running into clusters by too hasty a crystallization. By a judicious management of the heat, and sometimes by addition of a small quantity of rectified spirit towards the end of the evaporation, selenites may be brought to form in fair and well shaped crystals at the bottom of the vessel.

† Vide Note on Experiment II.

(*) Lewis's New Dispensatory, p. 461, edit. 2.

does

does not seem to have any great effect in composing the medicinal qualities of the waters.

Sal.cath.amar. The next body that comes under our consideration is the spurious Glauber's salt, or sal. cath. amar. There does not, however, seem to be the least reason to authorize our belief of its presence in the Bath Waters. Their taste by no means resembles those of this kind, and the residuum left on evaporation, gives not the least sign of it. Were this salt contained in the waters, it might be easily detected by this means, as the vitriolic acid is not separated from magnesia by the heat necessary for the evaporation; and then the hexagonal prismatic form, bitter saline taste, large size, and easy solubility of its crystals, would soon distinguish it from all others of this kind. The crystals, indeed, which appear on evaporation of the Bath Waters, are of the same form with those of the magnesia Glauber's salt, and in some degree of a saline bitter taste, as all salts that have vitriolic acid in their composition are; but that is extremely slight

slight in comparison with the other. They are likewise of small size, and not soluble, unless in a very large proportion of water, which sufficiently distinguishes them from those of the sal. cath. amar. which is soluble in as small proportion of water as any saline substance we are acquainted with.

The next substance that presents itself to our enquiries is Alumn. *Alumn.* The Bath Water, when nearly evaporated, has some degree of an austere, bitter taste, but does not possess that nauseous, sweetish one, which is always inherent in alumn. A solution of a fixed alkaline salt, causes, indeed, a white precipitation, but by no means in the flocculous form in which the earth of alumn is always precipitated, nor is any part of the precipitate re-dissolved, which is always the case, when the fixed alkali is not added in sufficient proportion to saturate the superabundant acid contained in the alumn. Add to this, that the earth of alumn is equally precipitated by caustic, as mild al-
K
kalies,

kalies, which is not the case with the Bath Waters.

On examination, likewise, of the residuum of the Bath Waters, no marks of alumn are to be found ; the saline particles are all hexagonal or cubical, and of small size ; whereas alumn, as was before observed, shoots into large, angular masses, consisting of eleven planes, five of which are hexagonal, and six quadrangular. Alumn, likewise, is much more soluble in water than the salt thus obtained ; the former requiring only about ten times its weight of water to dissolve in, but the latter infinitely more. On the whole, we have no reason to think alumn to be an ingredient in their composition.

We now come to the last
Aërial bodies. head of Impregnations, viz.
Aërial Bodies ; of these, the first mentioned in our catalogue is *Common Air*.

This seems to be very
Common air. sparingly contained in the Bath Water, when fresh, as fewer bubbles are observed in it, when placed under the exhausted

exhausted receiver *, than in water that has stood some time exposed to the atmosphere. This observation may, indeed, be applied to many springs, as they are all found to contain it in less quantity when fresh, than after remaining some time in an open vessel. Probably to this, among other causes, it is owing, that some waters become fit for several purposes, on standing some time exposed to the air, such as the solution of several bodies, &c. which they were not when fresh drawn. Thus if a saturated solution of any saline substance be placed under a receiver, and the air exhausted, the salt is largely precipitated, as the air separates from the water, and, on its re-admission, is slowly re-dissolved, as the water again acquires its proportion of air. The air, likewise, contained in these waters, must be highly rarefied by their heat, inso-

* Though the Bath Waters, fresh from the spring, shew but little marks of their containing air, by the Experiment mentioned above, yet, when grown cold, and having been exposed some time to the air, it exhibits the same appearances with common water.

much as to be dissipated nearly on their first communication with the atmosphere, before it could be possible to make them the subjects of our experiment. Thus we see common water, that has been boiled, or strongly heated in an open vessel, gives, for some time after, very little marks of containing air, exhibiting few or no air bubbles under the exhausted receiver, and freezing without any increase of bulk. If what has been suggested by an ingenious * Writer be true, that several disorders, as glandular obstructions, &c. are owing to drinking water deprived of its air, this would be a good reason against the use of boiled water for common drink, which many prefer, and is recommended by several Physicians, and has, indeed, some advantages ; or, at least, not to use it until it had remained a sufficient time exposed to the atmosphere, to recover its proportion of common air. It seems probable, that, in the Bath Waters, the fixed air, which we shall next treat of, supplies that deficiency.

* Dr. Percival, of Manchester, on the pump-water of that place.

Although common air seems to be contained in the Bath Waters but in small proportion, this is by no means the case with the fixed or me-*Fixed air.* phitic air, whose presence here is very evident, and is probably one of the greatest sources of their admired qualities. The sparkling appearance, pungent taste, and, on many, if taken in large quantity, inebriating effects, are sufficient evidences of this. Perhaps, likewise, the odour mentioned by Dr. Lucas, as prejudicial to weak lungs, and of an acid pungency, might be more owing to this, than to the volatile vitriolic acid to which it is usually attributed. These, indeed, may be very easily mistaken for one another, as it is not improbable that an acid is always either united with, or makes part of the composition of fixed air, since even that, when accumulated in large quantity, as on the surface of fermenting liquors, is found to change the colour of vegetable blues to red. Chemical experiments, likewise, confirm our opinion of this impregnation, which their sensible qualities had indicated. The pre-

precipitation of the lime from lime water, on admixture of the Bath water, when fresh, and the ceasing of this effect on its standing exposed to the air, the film produced on the same by the steam of fresh drawn Bath water, conveyed by a bended tube on its surface, prove this very clearly. To this, likewise, is owing the bursting of the bottles, if corked up as soon as filled from the spring, and the sensible diminution of the bulk of the water, on standing a few minutes exposed to the air. To this, however, it may possibly be objected, that, if the Bath water contained fixed air in large quantity, its effects on the human body, so far from being salutary, must be highly prejudicial, since that substance is known to cause deleterious, and even fatal effects, witness the many accidents that have happened from too near an approach to a vessel of fermenting liquor, whose effluvia, which we know to be composed principally, if not altogether, of fixed air, produce the most sudden and fatal consequences to animal life, that we are acquainted with.

In

In answer, however, to this, we may alledge, that, although we own the effects of fixed air, when accumulated in large quantity, to be as thus represented, yet, when united with a certain * proportion of common air, it becomes harmless, and may be even respired with safety. It is remarkable of fixed air, that its pernicious effects seem chiefly exerted, when taken in by respiration, and that the same substance, which, received into the lungs, should induce an almost instantaneous † paralytic torpor on

* Probably to this admixture it is owing, that the effluvia of the Bath, and other waters, which contain fixed air in substance, do not, when taken in by respiration, exert any of the pernicious effects on the human body, belonging to this substance in its separate state.

† This is to be understood of it only as taken into the stomach in a certain proportion, as, even there, if accumulated in too great quantity, it exerts its effects similar to those produced by it when taken in by respiration. Thus a small quantity of rectified spirits (for the time at least) stimulates and invigorates the stomach, and powers of digestion; but, if taken in over proportion, debilitates and hurts their faculties, and, if the quantity be very large, induces a sudden paralytic torpor of all the vital powers.

the vital organs, should, when taken into the stomach, prove a powerful and invigorating stimulant.

The celebrated effects of these Waters, in restoring weak stomachs, and enabling them to retain food, are, in all probability, owing to this part of their impregnation. To the dissipation likewise of this volatile substance, may be ascribed the small effects which these waters produce when drank cold, or at a distance from the spring, compared with those produced by them when fresh.

The common saline mixture, called, from its effects, *antiemetic*, affords a striking analogy to the effects of Bath water, in this respect, as this was found to exert none of its antiemetic qualities, unless taken during the effervescence; and by the account given of it by Sir John Pringle, its * antiseptic effects were much more observable when taken in this manner, than after that had ceased. For this reason that learned and judicious practitioner has

* This is likewise confirmed by Mr. Macbride's experiments.

delivered an elegant formula, for the exhibition of this preparation in the act of effervescence, whereby its effects of this kind may be best preserved. The nature of this substance seems to have been little understood by most of the authors who have written on this subject; some supposing it to consist of “iron * minutely subtilized,” whereas it is often found in large quantity in those waters that give not the least sign of their containing iron; witness those of Buxton, in Derbyshire; others calling it an ætherial spirit, with many vague and indeterminate appellations besides, to which no proper idea can be affixed. To give a farther account of this substance would exceed the limits of our work, and there is less necessity for an attempt of this kind, which must be infinitely inferior to one which the world is in daily expectation of, from the celebrated Dr. Black, Professor of Chemistry at Edinburgh. We may be assured, that the Bath water contains mephitic air in large proportion.

* Sutherland on Bath waters. P. 8. Ed. 2.

Review of the Experiments, and Deduction from them, concerning the Contents of the Bath Waters.

From a review of the above reasoning and experiments, we find, that out of the substances which we mentioned as possible native impregnations of Mineral Waters, those of Bath contain the following :

Table of the Contents of the Bath Waters.

I. Saline bodies.	{ Simple.—1. Vit. acid per fe. <i>Qu.</i> ?
	{ Compound.—2. Common salt in small quantity.
II. Inflammable bodies.	{ 3. Hepar sulph. cum calce vivâ, in large quantity.
III. Metallic bodies.	{ 4. Iron, one-thirty-seventh and a half of a grain in a pint of the water.—Lucas.
	{ 5. Lead. <i>Qu.</i> ? if this is not an accidental impregnation.
V. Earthy bodies.	{ 6. Selenites, in large quantity.
V. Aërial bodies.	{ 7. Common air. <i>Qu.</i> ?
	{ 8. Mephitic air, in large quantity.

P A R T IV.

Application of the Whole to the Purposes of Medicine.

WE now come to the last, and most important part of our Work, viz. the application of the foregoing to the purposes of Medicine.

And here we would not have it understood, that we mean to give a general account of the effects of the Waters on the human body, and of the several disorders in which their use may be advantageous or prejudicial, with the several periods of each, at which they are to be recommended or forbidden, &c.

Such a work, which might not improperly be termed the more strictly medical part of an essay of this kind, though

highly useful, can only be the result of long observation, and extensive practice, and would, moreover, if properly performed, be much too voluminous to come within the limits of a book of this size. We, however, presume to flatter ourselves, that the method we have chosen, will not be deemed entirely useless to the publick, though formed in a much more contracted design than the former. We propose, then, the Experiments, before related, as the foundation of our plan, and hope to render them, and the deductions to be drawn from thence, of some service to the practice of physic relative to the Waters. This seems to have been, and, indeed, we must own, not much to the honour of the Profession, hitherto purely empirical, and a course of food and medicines has been prescribed, with little alteration, for a long series of years, to be taken with the Bath water, without any view to the chemical effect produced by their admixture, or what might be the consequences of such a combination. It will here, probably, be alledged, that experience is the best guide
in

in such cases, and that the food and medicines, the propriety of whose use, in such circumstances, had stood the test of time, could never be properly disproved by any theoretical reasoning to the contrary. Had we our choice of one of these only for our guide in such cases, this would undoubtedly be true, as one good practical observation is of more advantage to science than all the unsupported theory that the world ever produced. But is not Reason an excellent companion to Experience? Is not the latter of small value, when destitute of the former to direct its applications? Is it not a duty which a Physician owes to the public, to search diligently for amendments in his practice, and not rest indolently satisfied with any peculiar method, so long as there is, as there always will be, a rational prospect of improvement; and, when he is satisfied of this, it is his duty to embrace it, without any regard to the quarter from whence it may be derived. This, we hope, will plead in excuse of this part of our Work, and of the directions here laid down, which we
only

only mean to offer to the consideration of, not impose them on the public, as certain rules to be indiscriminately followed, as we own we have great doubts concerning several of the circumstances mentioned. We hope, however, we have inserted nothing wherein we have not, at least, some degree of probability on our side. A work of this kind is certainly capable of great improvement; and the Author of the following sheets is fully conscious that he has proceeded but a very few steps, and that there is still a large field for any succeeding writer to exercise his genius in. He hopes, however, it will plead in his favour, that no book he has yet seen, has been wrote professedly with this view, and will think himself happy, if, by his means, any future Author may be induced to throw some farther light on this subject, hitherto so little considered.

We beg the Reader's pardon for this digression, and shall now proceed to give the plan of the remaining part of our Work, which, as it is mostly deduced from
our

our Experiments, and chiefly regards the composition of the waters, and the changes produced on them in various circumstances, may be said, in opposition to that before-mentioned, to be wrote on a pharmaceutical plan.

We propose, then, to consider as follows :

I. In what state the Water possesses its medicinal qualities in the highest degree.	<i>In what state Bath Waters are in greatest perfection.</i>
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When we consider the nature of the substances with which the Bath water is impregnated, we shall have little doubt with regard to our determination of this question. Out of the six substances that enter into its composition, one, and that perhaps the most important, viz. the mephitic air, is of so fugitive a nature, as to be in a great measure dissipated, soon after its exposure to the atmosphere. The chalybeate one, likewise, whether from its peculiar nature or qualities belonging to it, or from its slightness, seems remarkably soon destroyed; the water scarce giving any signs of it, except

cept examined soon after its rise. In all cases, therefore, where the patient is able to bear them, and the effects of the water are wanted in their full extent, these are undoubtedly in greatest perfection, when drunk at the fountain head. Many cases, however, may be supposed, in which, although the use of the waters, in some respects, may be adviseable, yet the effects of the mephitic air may prove too violent a shock for a tender frame, especially many female ones, to endure. In such cases, by suffering it to stand a few minutes after it has been drawn, this substance will be, in a great measure, dissipated, and its stimulating qualities nearly destroyed, or, at least, much abated. It is probable that the good effects produced by drinking these waters, in many scrophulous, leprous, and other cutaneous disorders, do not depend so much on the volatile part of the impregnation, as that which is more fixed, viz. the combination of sulphur with an earthy substance. As in cases of this nature a considerable portion of the good effects of the waters depends on their being taken in large

large

large quantity, often to the amount of several quarts in a day, should these waters be drank fresh, in so large proportion, it might be productive of some troublesome consequences, by over-heating the body, &c. In such cases, therefore, it might be adviseable not to drink the waters at the pump, but more at leisure in private, and that not until their heat, on which their stimulus in some measure depends, was abated. Care, however, should be taken, that it be not suffered to stand so long as to cause any precipitation, as this might be productive of the loss of many of its valuable qualities *.

In all cases, however, where the Bath waters are meant to act as restoratives†,

* As the chalybeate impregnation in the Bath waters, would, by this management, be lost; if it should be thought proper to restore it, as it is sometimes imagined to be of service in disorders of this kind, that may easily be performed by the addition of a few drops, two or three, for instance, of a saturated solution of green vitriol in water, to a pint of the Bath water.

† To those to whom the Bath waters are prescribed with this intent, and whose situations are such as do
not

and, of consequence, their stimulus, in some degree at least, must be of service, we would always advise them to be drank fresh at the spring, and to moderate their effects, if too powerful, rather by lessening the quantity, than using them when deprived of some of their serviceable qualities. It is observable likewise of these waters, and, indeed, of all others that possess this impregnation, that their heating qualities are much less perceived, when the quantity to be taken is divided into a number of small doses, than when several of these are accumulated into one, even though the quantity taken in the former case should, on the whole, exceed the latter. Thus one pint of the water drank at once, is found to have greater effects in raising the pulse,

not admit them to venture out, we would recommend a bottle with a ground glass stopple, (such as we commonly see in Apothecaries shops,) for the conveyance of the water from the spring to their houses, in place of those now used, which are closed with a cork. Such a one might be easily fitted to one of the tin machines for carrying the water, and retaining its heat, commonly used.

and

and heating the body, than three half pint^s drank at an hour's distance between each. In cases therefore of the last mentioned kind, it should seem adviseable, to divide the quantity to be taken in a day into a number of small doses, to be taken at moderate intervals, by which means its stimulus would be less sensible, and, probably, more permanent.

The subject now before us naturally leads to another question, viz. How these waters bear transportation? or, in other words, what alteration of their qualities is produced by standing? In order to explain this more effectually, it will be necessary to make a short recapitulation of the phœnomena that appear in these circumstances.

What alterations are produced on the qualities of the waters by standing.

It appears, by our experiments, that the Bath water, newly pumped, emits a large quantity of air bubbles, which are plentifully evolved from every part of it, and that this impregnation is so volatile, that it can scarcely be carried any distance, without

out losing, in a great degree, that sparkling appearance, and pungent taste, so remarkable in it when fresh. Its chalybeate taste and qualities are then much diminished, and on remaining a little time exposed to the air entirely cease.

On cooling, the saline taste, and that of the hep. sulph. cum calce vivâ become much more remarkable, and, indeed, some alteration seems to take place in the last mentioned impregnation, as the water then gives a green tinge to the vegetable blues. If exposed to the air it soon assumes a wheyish turbid appearance, and lets fall a light ash-coloured precipitate, and the latter happens in some degree even in close vessels, though the change of colour is not so remarkable. From these appearances we are induced to believe, that the common opinion, that the Bath water loses most of its valuable qualities on standing, is not ill founded.

The fixed air and chalybeate impregnations are, undoubtedly, destroyed, and the hep. f. c. calce vivâ seems to undergo a de-

decomposition of its parts. A circumstance happens here that is far from being common in waters of this kind. Most of those that contained fixed air along with a chalybeate impregnation, bear transportation very well, and when carefully closed up at the spring, may be carried to any distance, with scarce any diminution of their valuable qualities. The Bath waters, however, which contain both these impregnations, and the former of them in very large proportion, and although the bottles containing it be closed up with the greatest accuracy, as soon as filled from the spring, on their being again opened, give very little marks of the chalybeate impregnation, and scarce any of the aërial one. This alteration seems remarkable, as we cannot suppose it possible for the fixed air to have escaped, especially as we see it retained, in like circumstances, in many other waters. The cause of this, however, seems as if it might be explained as follows.

All the preparations, by which sulphur is rendered miscible with water, both by
means

means of an alcali and quick lime, are in some degree decomposed on such admixture, and the latter more easily than the former. As we have the utmost reason to believe, that the last mentioned combination makes a part of the impregnation of the Bath waters, it is probable that such a decomposition takes place here, the quick lime and the sulphur separating from one another. In that case the quick lime, whose strong affinity with fixed air has been before taken notice of, being now at liberty, attracts that contained in the water, and is thus rendered insoluble, and makes part of the precipitation observed to be formed in the Bath water on standing.

This accounts for the sparkling appearance, and pungent taste not being observed on the bottles, containing the water, being again opened, as the mephitic air is then in a fixed state, and strongly united with the lime. By this it should seem, that the Bath waters can serve very few useful purposes in medicine, when used at a distance from the spring, their impregnation
with

with fixed air being thus destroyed, and the chalybeate and sulphureous ones nearly so. Some small impregnation of the last mentioned kind may, indeed, remain, as even mild calcareous earths render sulphur, in some degree, miscible with water; but then this proportion of it is extremely small.

We can therefore say very little in commendation of their use at a distance from the spring, as they seem to be then little more than simple water impregnated with a large portion of selenites, and a small one of common salt, which certainly are not impregnations likely to serve many useful purposes in medicine. Much has been said, formerly, of the seasons of the year at which they are in the highest perfection; but, by what we are able to judge, the virtues of the waters * remain the same

* We desire to have it here understood, that we do not mean to insinuate, that every time of the year is equally proper for the drinking the waters. Experience shews the contrary. We only mean, that the qualities of the waters are not altered by these. How
one

at all of these, as the origin of the springs probably lies too deep to be affected by rains, frost, heat, or other changes of the atmosphere.

How the Bath Water is altered in its qualities by admixture of other substances?

II. The next question that occurs to our consideration is, how the Bath Water is altered in its qualities, by admixture of other substances, which we may suppose to be taken along with it, in the way of medicine? And here we beg leave to repeat what we before said, viz. that we do not intend to argue on the propriety or impropriety of prescribing the following substances to be taken with the waters any otherwise, than as regards their pharmaceutical intention, as to the compound they may form with, and assist or defeat the effects of them.

Alkaline salts.
Mild.

It appears by our Experiments, that fixed mild alkaline salts added to the Bath water, caused a

one time of the year may suit the disorders recommended to these waters, better than another, is a medical question which we do not profess to enter upon.

total

total decomposition of its parts, the calcareous earth separating from the sulphur, and the alkali uniting with it in its place; while the fixed air is absorbed from the alkali by the caustic calcareous earth, which thus becomes mild and insoluble in water, which is the cause of the white precipitation so observable on such addition.

The like decomposition happens with the caustic alkali, *Caustic.* save that, this supplying no fixed air, the lime still remains dissolved in the water, and no precipitation is observed*. The same happens on *Vol. alk. mild and caustic.* addition of the vol. alkalies, though in a less degree.

From their observation of this decomposition, many writers have concluded,

* It was before remarked, that if this Experiment be tried with the Bath water fresh at the spring head, some precipitation happens, which is probably occasioned by the absorption of the fixed air, (which is so largely contained in the Bath water fresh drawn) by the quick lime, set loose from the sulphur by the alkali.

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that

that all substances of this kind were very improper additions to the Bath waters ; and this remark is, undoubtedly, in general very just, as we can never expect the original effects of the waters, after the addition of a substance, which so highly alters the nature of their composition. By our Experiments it appears, that the aërial part of their impregnation is in a great measure destroyed by such addition, being absorbed by the earth.

In all cases, therefore, where the restorative qualities of the waters are most desired, in which this substance bears a principal part, this addition is by no means adviseable. Perhaps the propriety of its use in other cases, where this part of the impregnation seems not the most efficacious, may likewise be doubted, as the sulphureous impregnation is altered by such addition in its nature from an *hepar sulph.* with quick lime, to a true *hepar sulphuris*.

Notwithstanding, however, these objections, the force of which we acknowledge, it is not yet improbable, that alkaline salts
may,

may, in some cases, prove an useful addition to the Bath waters.

Obstinate costiveness is an effect of theirs much complained of, which frequently retards their good effects, and sometimes disappoints our hopes from them, by preventing their use. In consequence of this, medicines of the purgative kind are frequently necessary. These, however, agree often very indifferently with many weak stomachs and bowels, such as make many of the cases that seek relief from these waters. Could a medicine be found out, that would obviate this inconvenience of them, it would probably be of great service in extending their use. It does not seem improbable, that fixed alkaline salts, added to the Bath waters, might supply our wants of this kind. The qualities of the true hepar sulph. in keeping the body mildly open, without irritating the bowels, are well known, and their application seems well adapted to the removal of this troublesome consequence, so frequently attending the drinking of the waters.

If used occasionally in small quantities with them, it would probably act as a mild eccoprotic, without any necessity of confinement, or restraint of moderate exercise, both of which are so prejudicial to the generality of those cases, recommended to these waters for their cure. An addition of this kind likewise promises to be of service on another account.

Among the many complaints that find benefit from these waters, those of the bilious kind have not the least share.

It is observed of these disorders, that when the secretion by the kidneys is increased on drinking the waters, it is a favourable symptom, and in general prognosticates, that the patient will receive benefit by them*. It frequently, however, happens, that they do not take this direction, and in such cases, unless they run off

* The same may be said of leprous, and other cutaneous disorders, in which the use of these waters is advised, as diuretic medicines are found in all of them of the greatest service.

by stool, or a plentiful diaphoresis, they remain a long time as a dead weight on the stomach, impair and pall the appetite, and sometimes aggravate the very disorders they were intended to relieve. A substance, therefore, which would encourage the determination of the waters to pass off by the urinary secretions, and at the same time keep the body mildly open, must needs be a valuable acquisition. We are inclined to think the fixed alkali might be of service in both these intentions, and humbly recommend the trial of it to the Faculty, as conducive to such a purpose. Perhaps it might be most proper to make use of it with this intention in its caustic state; but this will be best determined by experience.

We mentioned in our Ex-
periments, that the acids seem-
ed to have no perceptible effect in altering
the qualities of the Bath waters. In all
cases, therefore, where acids are proper, we
do not find any thing in the composition of
the waters that forbids their use. When

Acids.

mixed with them, in form of an elixir, or dulcified spirit, a very grateful compound is produced, and this circumstance may be of service in reconciling the waters to the taste of many, to whom, in their native form, they were very disgusting. On trial, the dulcified spirit of nitre seemed to form the most agreeable compound of any of the acid preparations with the waters. Possibly, likewise, these may be of use in encouraging the determination of the waters to pass off by the kidneys.

As these organs, however, are differently affected in different people, by several substances, where this secretion is necessary to be encouraged, it may be of service to make trial of acids and alkalies both in their turns, and, perhaps, even neutral salts, and to fix on such as we find most efficacious to fulfil such intention. It is probable, likewise, that in many cases where the waters are found too heating, an addition of this kind would moderate this effect of them, and enable the patient to take them in larger quantity, without exposing

posing himself to any inconvenience from that circumstance.

Should the neutral salts be judged proper, they may any *Neutral salts.* of them be taken with, or in the waters, without injuring their qualities in the least, the volatile vitriolic acid being weaker in its attraction to alkalies than any of the other acids, therefore no decomposition of the salt could happen. In some cases, where any inconvenience happens from the heating qualities of the waters, an addition of some of the more cooling ones of this kind, such as nitre, and regenerated tartar, might be of service in obviating these effects of them. The costiveness, likewise, before mentioned to be a common consequence of these waters, might be thus relieved, and their diuretic effects encouraged by these means. A judicious Physician will soon discern whether these, or the simple salts, as acids and alkalines, are most effectual in the several circumstances.

*Absorbent
earths.*

Earths of this kind, in their mild state, seem to produce little change on the qualities of the Bath waters, on being mixed with them. They may, indeed, perhaps, detain the volatile vitriolic acid, and hasten the precipitation of the ferrugineous particles, on which last account these substances must be always improper, where any dependence is laid on that part of the impregnation. If any addition of that kind should, however, be thought necessary, we would advise the use of magnesia rather than any absorbents of the calcareous kind, on account of its laxative qualities; whereas the calcareous ones rather tend to promote a costive habit, which is already but too frequent an attendant on those who use the Bath waters. It is possible that the opening effects of magnesia might be increased, on its being mixed with the Bath water, as it might, in part, by its attraction of the volatile vitriolic acid contained in the water, be converted into a purgative earthy salt. We can scarce, however, think, that the quantity
formed

formed in this manner could produce any great effect. As magnesia, however, by itself, possesses, in many habits, the quality of keeping the body mildly open, an addition of this kind might be often of service to be used with this intention, which it might, in many habits, answer as well, or better than alkalines or neutral salts, especially in those where acids abound in the first passages. It seems not improbable, that, when we desire to encrease the tendency of the waters to go off by the urinary secretions, that alkalines, or neutral salts, would be preferable to magnesia; but where keeping the body mildly open, and obviating acidities were the points aimed at, magnesia might be more efficacious.

Calcareous earths, in their caustic state, seem very improper additions, on many accounts, to the Bath waters.

It appears by our Experiments, that a copious precipitation was generated in them when fresh, on addition of lime water, which was undoubtedly caused by the lime in the lime

Lime water.

water attracting the mephitic air from the Bath water, and thus becoming mild, and of course precipitated. From this we may judge, that in all cases, where the mephitic air may be of service, that lime water must be a very improper substance to be joined to it, as it absorbs it instantly, and unites with it very strongly. Lime water added to the Bath water fresh, seems to impart no additional qualities to it, except a disagreeable empyreumatic taste; the calcareous earth being separated in an insoluble form, and nothing remaining of it except the ungrateful flavour before-mentioned. In all cases, therefore, where lime water may be prescribed to be taken with a course of the Bath waters, we would recommend them to be taken with the greatest possible interval between each.

Fig. of astringents and bitters.

Vegetable astringents and bitter substances, are often prescribed to be taken with, and frequently in the waters, as coinciding with their intention, and enabling the stomach the better to retain them. What are the effects
of

of these substances in general, united with the Bath waters, considered as a compound, we must own to be rather ambiguous. The vegetable astringents, we know, precipitate all the solutions of iron from their acid menstrua, which is the cause of that blackish or purple colour, produced on such addition. This would seem to forbid their use with any water, where the chalybeate impregnation was depended on for any good effect.

This argument, nevertheless, however specious, does not seem to be well founded, as the iron, although separated from its menstruum, is not precipitated to the bottom, but remains diffused through the body of the surrounding fluid, (as we see in ink) and might thus be received into the body along with the water. It is observable, that iron thus precipitated is very easily redissolved by all the acids*, even the vegetable, as we see by the ease with which spots of ink are

* Calces of iron, that precipitate spontaneously from chalybeate waters, are not so easily redissolved, as those formed in this manner.

taken out of linen, &c. by juice of lemons, or vinegar. It is probable, therefore, that the acid of the stomach would soon reconvert the iron into a saline state, and put it into a capacity of exerting its effects.

Some objections, however, remain against the use of these substances with the stronger chalybeates. The black colour, which they strike, is by no means to be chosen for a medicine, where it can be avoided, as it renders it very unsightly, and disgusting to weak stomachs; and, what is still more to be regarded, the taste of the chalybeate is by no means improved by such addition, becoming more nauseously styptic, as we may see by the difference of the taste of ink, from a simple solution of green vitriol in water. This objection, however, does not hold against their use (if deemed proper) with waters so slightly chalybeate as those of Bath. The taste of these is not very obviously injured by a small addition of this kind, and the colour being only changed to a light purple is not disagreeable. This objection, however, al-
though

though true in its full extent, affects only the simple astringents, or such bitters as are combined with them.

Most of the woods, barks, fibrous roots, stalks, and rinds of fruits, some leaves, and the cortical part of seeds, possess some degree of astringency ; whilst, on the other hand, the pulps of ripe fruits, simple gums, essential and expressed oils, balsams, gum-resins, and bulbous roots, are nearly divested of it. It is probable, therefore, that all the substances of the latter kind might be taken without the least alteration of the qualities of the Bath water ; and if the Physician should deem any of the former to be proper, a few drops of the elixir of vitriol, no incongruous addition, would restore the transparency, and improve the taste of the waters.

Few of these, we believe, *Metallic preparations.* are often prescribed to be taken at the same time with a course of the Bath waters. Nevertheless, as we have before mentioned some of the chalybeate-kind as likely, in some circumstances, to prove

prove useful additions to them, and as cases may occur, especially in disorders of the cutaneous kind, wherein the use of some of the antimonial, or mercurial preparations, may be adviseable, it may not be entirely useless to consider, what would probably be the consequence of their admixture with the Bath waters.

Iron.

In treating of this metal in a former part of our Work, it was remarked, that the Bath waters, poured on filings of iron, *dissolved them plentifully. It should seem, then, no improper method of administering this substance, to use it in this form, when we desire to add strength to the chalybeate impregnation. Were it thus taken immediately before drinking them, the solution of the metal might be performed in the stomach, and we might then rely, with more certainty, on the effects of the chalybeate. By this means, likewise, we might depend on the nature of the additional chalybeate impregnation being the same

* See Lucas on the Bath waters.

with that originally contained in the waters, which we could not do if the solutions of iron, in other menstrea, were used for that purpose.

Perhaps it might here be objected, that, according to the principles we had before laid down, concerning the necessity of an intercourse with the air, in order to the solution of this metal, no effects could be expected from it in this mode of exhibition; since this metal, as well as many other substances, is only active in a state of solution, which could not be expected in these circumstances, where all commerce with the air must necessarily be excluded. To this, however, it may be replied, that iron is very manifestly proved to be dissolved in the stomach, by the effects consequent on taking it in this form, which are produced by its being there reduced to a saline state. Now the volatile vitriolic acid, especially when dilute, is a more powerful solvent of iron than the acid of the stomach, which in strength and qualities approaches nearly to the vegetable.

Another

Another reason, however, may, with more plausibility be urged against this form of a chalybeate medicine. It is said of iron, given in substance, that its effects are very uncertain, owing to its solution depending on the quantity of acid present in the stomach, which, as that is more or less, occasions a larger or smaller proportion of the iron to be dissolved, and renders the dependence we should have on it, as a medicine, precarious, since its activity must be owing to a circumstance, concerning which we are not able to judge with sufficient certainty. Although this reason carries some weight with it, we cannot admit it to conclude satisfactorily against this form of administering this substance, either considered as a medicine by itself, or as added to increase the chalybeate qualities of the Bath waters. Of these we lately observed their power of dissolving it, and we may, moreover, add, that those to whom chalybeate medicines are, in general, of most service, are such as have a superabundant acid predominant in their stomachs, and in these the chalybeate seldom fails of
its

its effect, when given in its metallic state. By this means, likewise, its effects might be proportioned by nature, in some measure, according to the exigency of the case; as those stomachs which were most disposed to generate acid, which are generally the most languid, and in greatest need of a stimulus, would dissolve it most plentifully, and, of consequence, be most strongly acted on. Considered simply as a medicine by itself, we are induced to think this form preferable to many of the compound preparations, at least in some cases, since the metal thus acts as an absorbent of the acidity, which would not have been the case, had it been given previously united with an acid, as its effects would then have been simply astringent and stimulant. We mentioned before, that the mephitic air was probably a source of some of the good qualities of the Bath Waters. It is possible, then, that some advantage may occur in this mode of exhibition, from the generation of that substance in the stomach during the dissolution of the iron, when it is always copiously produced. It may not, there-

234 *How the BATH WATER is altered*

therefore, be, on the whole, unreasonable to suppose, that in those cases where chalybeates are proper, in which we are tolerably certain of the presence of an acid in the stomach, that this form may be preferable; but where that is doubtful, as in many scorbutic and cutaneous complaints, that it would be more eligible to use it previously combined with an acid, as in some of the compound preparations.

As to the compound preparations of this metal, that most commonly used, viz. the sal martis, might probably be employed with advantage for that purpose, as being sufficiently concentrated, tolerably certain in its effects, capable of being reduced to a standard, and not liable to be decomposed by any substance contained in the Bath waters. The same may be said of the solution of iron in the muriatic and vegetable acids as in the case of the tinct. mart. cum sp. falis, and the mars solubilis seu chalybs tartarizatus. Perhaps, however, the sal martis may be thought preferable to any of these, as being less liable
to

to uncertainty in point of saturation, since we have it in a crystallized form. One inconvenience, however, it is liable to, which is, that when used in a liquid form, as dissolved in water, the iron is apt to separate on standing, which renders the dose uncertain. The tinct. mart. cum sp. falis is not liable to this inconvenience, and on that account would be more eligible. As to the preparations of iron with an alkali, and with a neutral salt, as in the mars solub. alcalizatus, and the flores martiales, their use would be less advisable, as being more liable to decomposition.

We find, by our Experiments, that on addition of an alkaline salt to the waters, a considerable change was induced on their qualities. This would probably happen were the mars solub. alcaliz. used, the iron would be precipitated, and that too, probably, in a form not easy to be redissolved. With regard to the flores martiales, in which the iron is united with sal ammoniac, we are inclined to think that their effect would not be so certain, as the neutral salts
are

236 *How the BATH WATER is altered*

are at best but incompleat solvents of iron, and would in that case only serve to increase the bulk, without imparting any valuable qualities to the medicine. On the whole, the pure filings per se, a sol. of sal. mart. in water, or the tinct. mart. in sp. falis, seem preferable to any of the other preparations to be used, in order to increase the chalybeate qualities of the Bath waters.

Antimony. How the effects of this metal on the human body would be altered by an admixture with the Bath waters, is a question not easy to determine, and can only be known by a long attention to the consequences produced by it in these circumstances, under all its several forms. We will venture, however, to make a few observations on this subject, (which we offer only as hints) deduced from chemistry, and we own are not so perfect as we could wish, as the chemical history of antimony is very incomplete.

This substance, in its crude state, would probably not be affected by admixture with the Bath waters. Alkaline salts, indeed, and
even

even calcareous earths, in their caustic state, as lime water, act upon it by forming a hepar sulph. with the sulphur contained in it, by which its activity is increased. Whether this is done by the alk. or lime, forming with the sulphur a compound capable of dissolving the antimony, or by abstracting part of the sulphur, which rendered it inert, is a curious question. Did these waters contain an alkaline salt uncombined with any other substance, or a calcareous earth separate in its caustic state, they might then affect the qualities of the crude antimony; but as here the calcareous earth is already saturated with sulphur, no such change of them would probably occur. The vitriolic acid likewise, which we mentioned before, as contained in the waters, does not affect antimony combined with sulphur.

As to antimony, in form of regulus or glass, these are very seldom used *per se* in a solid form, except in the case of the vitrum antimonii ceratum, which would be probably not acted on by the Bath waters, as the antimony would be protected by its union with the wax.

As

As to the compound preparations of this metal, the saline combinations of it with the *vitriolic and †nitrous acids are nearly inert, and that with the muriatic too stimulant for internal use. The solutions of it, therefore, in the vegetable acid, are most commonly used, as the tartarum emeticum, and vinum antimoniale. How these would be affected by the Bath water would be a curious medical, as well as chemical question. The hep. sulph. cum calce vivâ, as we before observed, is not decomposed by any of the acids singly, but when these are combined with a metal, as in this case a double elective attraction ‡ might take place, as in the following scheme :

* Antimonium vitriolatum. WERLHOFF.

† Bezoardium minerale. Bez. Joviale.

From this character of the combination of antimony with the vitriolic acid, we may conclude, that if any portion of the reguline, or other preparations of antimony be dissolved, or corroded by the vitriolic acid in the waters, its activity would, by that means, be rather diminished than increased.

‡ Dr. Lucas does not seem to have thoroughly understood the nature of double elective attractions, when, from a notion of the strong attraction subsisting between the fixed alkali and the vitriolic acid,

he



If this should happen, we might be disappointed in our expectations from the an-

he asserted this salt could not be decomposed by any other means than by adding the phlogiston. Vitriolate tart. may be decomposed by a solution of calcareous earths, or metals, in any of the other acids, as in the following schemes.



timony,

timony, as it would be rendered nearly inert. Whether these preparations would be affected by the vitriolic acid in the water, affords room for doubt; we rather think not, as the vitriolic acid is in its volatile state, in which, its attraction to antimony seems inferior to the vegetable acid. As to the combinations of antimony with hep. sulph. as in the sulph. auratum antimonii precipitat. it does not seem probable that their qualities would be altered by admixture with the Bath water.

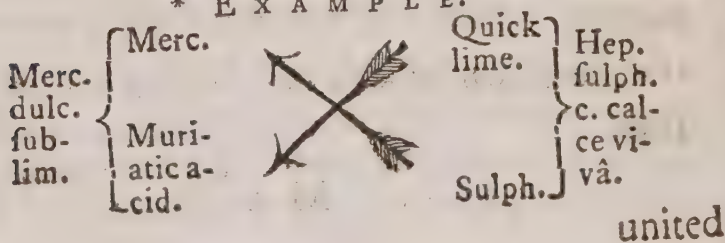
Mercury. The affinity between mercury and the vitriolic, seems more strong than between it and any of the other acids. Thus we see a yellow precipitate always formed on admixture of a solution of mercury in the nitrous acid, or of corrosive sublimate, with any water containing the vitriolic acid. This happens, in some degree, with the Bath waters, which inclines us to believe that there is a portion of the vitriolic acid contained in it (in its separate state,) exclusive of that which

which holds the iron dissolved *. It might be here objected, that we have before represented the volatile vitriolic acid as less strong in its attraction to other substances, than any of the other acids, and, consequently, could not decompose any substance, of whose composition they made a part; and this seems true with respect to alkaline salts, and, perhaps, some other substances, but does not hold universally. The vitriolic acid is found to be changed from its fixed to its volatile, and from its volatile to its fixed state, by being united with several substances. By mere exposure to the air, the volatile acid becomes fixed, and, by its union with iron, and several other substances, the fixed seems, in some degree at least, rendered volatile. It does not seem improbable, that the volatile acid may be rendered fixed by its union with mercury. Whether this be the case,

* This is rendered more likely by the blackish or purple colour it strikes with solution of galls, being heightened by an addition of a little lime water, or a few drops of a solution of any alkaline salt.

or that its attraction to that substance be nearly as strong in its volatile, as its fixed form, we cannot determine with certainty. If this be true, many of the mercurial preparations, especially the more active ones, must be altered in their nature, on admixture with the Bath water, and changed into a merc. emetic flavus, or turpethum minerale. We are not able to discover if any decomposition of the sulphureous impregnation of the water happens, which we might suppose possible, in the same manner as we before mentioned of antimony in like circumstances*. We are, however, inclined to believe this not to be the case, as the precipitation would then probably have been of a darker colour. These facts would lead us to think, that we could not depend, with any degree of certainty, on the effects of any preparation of mercury,

* E X A M P L E.



united with an acid, except its combination with the vitriolic, if taken in or at the same time with the Bath waters. It would therefore seem adviseable to omit the use of the Bath waters, during the time of taking the mercurial preparations commonly exhibited. Perhaps, however, if they were united with some of the gum-resinous substances, as is sometimes practised, they might be defended from the action of any of the substances contained in the Bath water, and their effects thus secured.

We beg leave, however, here to repeat again, what we formerly said, that we offer these things only as conjectures, that, we think, bear some appearance of probability.

As the compound formed
by admixture of milk with the *Milk.*
Bath waters, is frequently prescribed to be taken in the way of medicine, it will not be entirely useless, to consider what may be the chemical effects of such a combination.

The Bath water, in the proportion of equal quantities, produces with milk heated to the boiling point, a separation of its parts, the cheefy part dividing from the ferous, in form of a loosely cohering curd. In these proportions, however, the separation is by no means perfect; but when made with two parts of Bath water to one of milk, the curd is then separated nearly completely. The whey, thus made, has little peculiarity of taste, and, indeed, in most of its qualities, by what we can learn, differs little from common whey, made with an acid substance, and diluted with water. By the time and apparatus necessary for the making it, the aërial impregnation is entirely dissipated, and it is not improbable that the sulphureous one may be decomposed by such addition, as the whey, thus made, possesses very little, if any, of the peculiar taste which the Bath water acquires on standing. On the whole, this composition, however specious, appears to us to be a very incongruous one, for the reasons above mentioned; and the common pretence alledged in defence of it,
that

that of reconciling the stomachs and palates of many to the Bath Water, who would not, else, be able to bear it, seems by no means sufficient to justify its use. Most of those who come to Bath for stomach complaints, receive the greatest benefit from that part of the impregnation, which, by this means, is entirely dissipated, not to mention that the bulk of the dose is thus increased one third part, which is a matter of great consequence in such cases. In these circumstances, therefore, if the Bath waters give disgust, or are with difficulty retained on the stomach, it would be more advisable to reconcile their use by some grateful aromatic addition, and by lessening the doses of it, than by using it when its qualities are impaired, and its bulk considerably augmented. If whey, however, be deemed a necessary addition, we would advise a proportionable quantity of fresh whey already made, to be added to the water fresh drawn, and to be immediately drank, by which means the qualities of the waters will be little injured. We are, indeed, of opinion ourselves, that whey drank at the

same time with a course of the waters, especially in the spring season, might often, in many complaints, especially those usually called scorbutic, be a very proper prescript, as contributing to obviate the costive habit, and heating effects, which these waters so frequently occasion. We cannot, however, see any necessity for mixing it with the waters, as its good effects would be equally powerful if taken at some interval. On the whole, we are inclined to believe, that this remarkable effect of the water on milk, has contributed much to recommend the product of such a combination as a medicine, as imposing, by a kind of juggler's contrivance, on the understandings of many, and persuading them to believe, that so remarkable a production must have some very uncommon virtues. To sum up all; this preparation seems incongruous to the general intentions wherewith the Bath water is prescribed, and not qualified to answer any purpose which might not as effectually be done by other means.

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We now come to the third and last question which we propose to consider, which is, *Whether an artificial Bath water be practicable, &c.* Whether an artificial Bath water be practicable to be made? what preparation approaches nearest to it? and to what purposes it may be applicable in medicine? In order to determine this question properly, it will be necessary to consider it separately under its several heads, as here divided.

As to the first of these, viz. Whether an artificial Bath water be practicable? from a review of its contents, we might be, at first sight, tempted to pronounce this to be far from a difficult operation. As to those parts of its impregnation which seem most efficacious, viz. the sulphureous, the chalybeate, and the aërial one, the first of these has been proved, by our Experiments, to be very easily performed; and the two latter, according to the experiment before cited from Dr. Lewis, mentioned in Neuman's Chemistry*, appear to be equally so.

* Page 176.

By forming, therefore, a combination of sulphur with water, by means of quick lime, and adding this compound (previously filtered) to a portion of green vitriol and quick lime, (which last equally decomposes the vitriol, as well as the alkaline he recommends,) in the manner he mentions, we might expect to see formed a water possessed of sulphureous, chalybeate, and aërial impregnations, in the same manner with the Bath waters; capable of being made to any degree of strength, and wanting nothing material except the heat, which might easily, by immersing bottles of it in boiling water, be imparted to it.

Notwithstanding, however, the speciousness of this reasoning, we are inclined to believe, that a compound thus formed, though it might be applicable to some useful purposes, and in many cases, perhaps, worth the trial, when the fresh Bath water cannot be procured, would prove much inferior, on many accounts, to the Bath waters themselves. Artificial preparations of this kind must labour under several disadvantages. First, The proportions

tions of the several ingredients of which the Bath water is composed, seem very happily adjusted to form a compound almost universally agreeable to the stomachs and palates of mankind, and, probably, on this, no small share of their medicinal efficacy depends.

These proportions are unknown to us, and, indeed, almost impossible to be either ascertained in the original, or exactly adjusted in any artificial imitation of them. According, however, to the method by which we might expect to imitate them, the chalybeate impregnation must be vastly stronger in proportion to the other parts of its composition, than in the Bath waters themselves, in order to produce an equal quantity of mephitic air. This would render the taste disagreeably astringent, and in all probability disgusting to weak stomachs, which can ill bear a strong chalybeate.

On supposition, however, that the aërial impregnation might be mechanically performed, which, it is said, may now be

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done, and that then we might add the chalybeate impregnation in what proportion we thought proper, another difficulty, however, still remains. Calcareous earths possess the quality of rendering sulphur miscible with water, only in their caustic state, or when deprived of their fixed air. The only method we have of performing this applicable to practice, is by calcination. This, however, whether from any remains of some inflammable * substance united with the earth, or from some other cause, is not yet determined, never fails of imparting a strong empyreumatic taste to the water with which it is mixed.

A great chemist, however, is of opinion, that this is not the only method by which calcareous earths may be deprived of their air, and rendered miscible with water; since we find it in large quantities

* This seems not unlikely, as the lime made from shells, which we might suppose to have some animal inflammable substances adhering to them, is found to impart a stronger empyreumatic taste to water, than the lime made from stones.

dissolved in many springs, which possess none of the empyreumatic taste, so distinguishable in lime water. How this may be performed has hitherto eluded our search, and may, possibly, continue to be reckoned among those wonderful phenomena of Nature, for which we are not able to account by any visible means. The chemists, however, are of opinion, that this may be performed by several methods; and to the difference of manner in which the earth is deprived of its air, they attribute the different tastes which these waters are observed to possess.

That there is a just foundation for these suppositions, appears from the Bath waters, which, although they contain manifestly a calcareous earth in a caustic state, united with the sulphur, have nothing of the empyreumatic taste of the compound, which, in other respects, resembles it. Many of the petrifying waters, likewise, which contain calcareous earth in large quantity, which they soon deposit when exposed to the air, in the same manner

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with lime water, are wholly divested of the empyreumatic flavour belonging to that substance.

These reasons, in our opinion, weigh very strongly against the probability of entire success from an attempt of this kind. Nevertheless such trials may not be without their use.

The Bath waters, as was before observed, lose many of their valuable properties on standing; could any preparation, therefore, be invented, which might in any ways resemble them in their effects, some deficiency, in point of agreeableness, might be complied with. It is not impossible, that, by repeated trials, the proportion of the ingredients might be so adjusted, as to form a compound not very disagreeable to the taste. If this could be effectually performed, it might be of great service to many, whose state of health, or circumstances in life, do not allow them to take so long a journey, as this place must necessarily be from many parts of the kingdom. How it may be best done we shall next consider.

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Preparation resembling BATH WATER. 253

We now come to the second division of our question, which is, What preparation approaches nearest to the Bath water in taste and qualities? For the reasons above given, we must not expect any very exact imitation of them, especially in the first of these articles, but the preparation, which seemed on the whole most to resemble them, was as follows :

What preparation approaches nearest to Bath water, &c.

Let ʒij. of washed flowers of sulphur be ground with ʒss. of quick lime; during the trituration, add gradually ℥ij. of pure rain, or distilled water; strain it off. Take then a strong glass, or stone bottle, of a quart contents, put into it ʒss. of green vitriol, and ʒij. of quick lime*, (fresh burnt;) pour on it the forementioned liquor, and cork it close up immediately. This preparation will keep, close corked, three

* Lime made from lime stone is preferable to that made from shells, as the latter is observed to give more of an empyreumatic taste. As, however, they both possess it in some degree, it seems to give some foundation for the supposition, that all lime stone were originally formed from the exuviae of animals.

254 *Preparation resembling* BATH WATER.
or four days, without any remarkable separation of its parts.

When wanted for use, ℥ij. of it may be added to ℥vj. of common rain, or distilled water previously heated rather above the degree of the Bath water, and drank immediately.

This composition, thus diluted and heated, resembles, in some measure, the Bath water, though we own it to be very deficient in point of agreeableness of taste. The proportion of the ingredients that form this composition to one another, and to the fluid with which they are united, is not easy to be ascertained, as we know not in what quantity the hep. sulph. c. calce vivâ is miscible with water, and as to the fixed air, that is still less determinate. The proportion of the iron, however, in ℥viij. of the preparation, is something less than two grains of the green vitriol, to ℥viij. of the fluid, and as each grain of this is supposed to contain one-third of a grain only of iron, ℥viij. of this mixture contains two-thirds of a grain of iron, which, though:

though no great quantity, is yet vastly stronger than the Bath waters, which, although their taste is evidently chalybeate, do not contain above one thirty-seventh of a grain in ℥xvj. of the water. The proportion, therefore, between the artificial preparation, and the native Bath waters, as to strength of chalybeate, is nearly as forty-nine and a half, to one, omitting fractions, which is a very great disproportion.

We now come to the last and most important division of the question, viz. To what purpose the artificial composition we lately mentioned may

To what purpose the artificial Bath water may be applicable in medicine.

be applicable in medicine? It would much exceed the limits of a work of this kind, and, moreover, require a great degree of practical experience in the effects produced by it, which we do not pretend do, in order to determine this question fully. For these reasons, we shall not enter into particular circumstances, but only give a few general hints, drawn from analogy, chiefly relative

256 *Use of the Artificial* BATH WATER.

relative to those kinds of disorders in which it is likely to be of service, or not, in supplying the place of the Bath waters.

As no fair trial has been yet made of it in practice, our reasoning on its effects can be only theoretical: As we have, however, great reason to believe, that it resembles the Bath water in most of the material articles in its composition, it will scarce be thought unreasonable, if we attribute some degree, at least, of the same effects to it. As we do not, however, pretend to alledge that it possesses the qualities of the Bath water entire, it will properly come under our consideration, to enquire how far this variation may influence its effects.

The principal differences between the artificial preparation, and the native Bath water, seem to be, that in the first, the taste (for the reasons before mentioned) is less agreeable, and the chalybeate impregnation stronger. As to the proportion of fixt air, which they respectively contain, it is not easy to determine; there is, however, sufficient proof, that it enters
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into the composition of each in large quantity : The Bath water, indeed, contains besides a portion of selenites, and a small quantity of common salt, neither of which form any part of the composition of our imitation of it. If it should be thought proper to make the resemblance more exact, a few grains of each of the last mentioned substances may easily be added. From the inactivity of the former, and small proportion of *both these ingredients, we cannot, however, think such a nicety at all requisite, or that the Bath waters themselves would be in the least injured in their medical virtues, should they be deprived of these parts of their impregnation. Although we cannot think this difference of any great consequence,

* In the table of contents of the Bath waters, it was there said, that it contained selenites in large quantity. This, however, is only to be understood of its proportion of saturation, in comparison with other saline bodies, it being scarcely perceptibly soluble. The real quantity contained in them is extremely small, in proportion to their respective bulks.

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258 *Use of the Artificial* BATH WATER.

yet the first we mentioned, viz. that of taste, is a very material one, and which must greatly enhance the value of the Bath waters, above every imitation of them that is deficient in this article.

This circumstance would prevent its coming into use among a considerable part of the cases recommended to these waters for relief. Great numbers of these consist of such as have injured their health by too free a course of life: Of these, the stomachs in general are very delicate and tender, and such as, being accustomed to great indulgence, we can scarce expect can be brought to submit to make a proper trial of a remedy, whose good effects must of necessity be slow, and often not sufficiently evident to compensate for the disagreeable circumstance of taking a medicine of an ungrateful flavour, whose dose must be large, frequently repeated, and continued for a length of time, before any considerable benefit can be expected from it. Of these we could have little security in their persisting in the use of it
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a sufficient time to make a proper trial of its effects ; and even if any should have sufficient resolution to attempt it, it is probable that the disgust it might occasion, would either prevent its being retained on the stomach, or so influence its effects, as to disappoint our hopes. It is a common observation of medicines that are given with the intent of strengthening the stomach, and powers of digestion, that, unless they can be made tolerable to the taste, little good is to be expected from them.

The chalybeate impregnation likewise, though in general well adapted to the cure of these complaints, would here, probably, on several accounts, be too strong to be ventured on, at first especially, as being then so apt to give disgust to weak stomachs, and as the irritation occasioned by it might prove too violent a shock in many of the cases recommended to these waters, which are often themselves, when fresh drawn, too heating, and would, probably, be much more so did they contain so large a proportion of the chalybeate

260 *Use of the Artificial* BATH WATER.

beate as is necessary to form the artificial one. Some degree of stimulus is generally of great service, but an excess in this point, especially in many female complaints, may be of dangerous consequence. The first of these reasons would seem likely to disappoint our hopes, in all cases where the stomach was, in any considerable degree, primarily or secondarily the seat of the complaint, as in many bilious and gouty cases the nephritic colic, indigestions, retchings to vomit, &c. such as females are peculiarly liable to, and other weaknesses of the alimentary canal, in all which the native Bath water is of great service. The large proportion of chalybeate, likewise, in the artificial Bath water, would render a trial of it improper in all cases where there was any degree of a feverish tendency, although on other accounts it might be likely to be of service, as it would most probably aggravate these complaints. This would forbid its use in many rheumatic cases of the acute kind, which often find great benefit from the Bath waters.

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Notwithstanding, however, these disadvantages, we are still inclined to believe, that there may some cases occur wherein the aforementioned preparation may form an useful substitute to them. Many complaints in which the stomach is little (at least obviously affected, such as leprosy, scrophulous disorders, scorbutic eruptions, and, in general, cutaneous disorders unattended with fever, seem particularly adapted to a trial of this kind. The sulphureous and chalybeate impregnations seem here to be of great service, as is proved by analogy of the good effects of these substances when given in the way of medicine in these disorders; and it is not improbable to suppose, that, from these parts of their composition, the Bath waters have gained a great part of the reputation they so justly merit in the cure of these complaints.

As, however, both the chalybeate and sulphureous impregnations may be taken in substance in much larger proportion than can be contained in any quantity of the Bath waters that we can suppose to be
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taken in a moderate space of time, it would, probably, be of great service could a method be invented of adapting the strength of the medicine to the circumstances of the patient, without increasing the bulk of the dose.

The artificial preparation above mentioned, seems likely to fulfil this intention, as it may be diluted to any degree, in the manner above-mentioned, without the least injury to its qualities. Although we excepted bilious cases out of the number of those in which our artificial preparation was likely to be of service, we desire to be understood to mean those only in which the stomach is so affected in consequence, as to make it doubtful if it would be retained. On the contrary, it seems likely to suit many complaints of the liver kind, especially obstructions of that viscus, (always excepting those attended with any degree of fever, in all which its use would be highly improper,) especially as it is possessed of a quality, the want of which sometimes prevents the use of the Bath waters,

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that of keeping the body mildly open, a circumstance of the utmost consequence in these complaints. From observation of this quality, we should imagine it likely to be of service in many colicky disorders, particularly the *Colica Piſtonum*, for the cure of which the Bath waters are so remarkable. If it should be found efficacious here, it would be a discovery of great importance, as this disease is chiefly confined to the lower rank of people, artificers especially, whose circumstances and employment would not permit them to make use of the waters themselves. Whether or no it would answer, we do not pretend to determine. Where, however, an opportunity of using the Bath waters cannot be had, we should, from analogy of its contents, and especially from the last-mentioned effect of it, recommend a trial to be made.

In cases, likewise, where the astringent and corroborant effects of the Bath water are required, as in many female weaknesses, barrenness arising from this cause, and
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264 *Use of the Artificial* BATH WATER.

other complaints of this kind, we should think this preparation likely to be of service, as the chalybeate impregnation, which is in these cases of great efficacy, is much stronger than in the Bath waters themselves, and may be increased at pleasure. The ecoprotic effects of the sulphureous impregnation likewise, seem exceedingly well adapted to obviate the heating effects of the chalybeate, and allow its use in larger quantity than otherwise it would be prudent to venture on. In chronic rheumatisms, likewise, where there is none, or but small degree of feverish diathesis, this medicine seems likely to supply the place of the Bath waters with good success, as chalybeate waters are found, in many stages of it, of remarkable efficacy; and the quality of this, lately mentioned, which is contrary to the generality of the native waters of this kind, would much encourage our expectations from it. The Bath waters have sometimes been found of great use in calculous, nephritic complaints. From analogy of its contents, and more especially from its possessing the last mentioned quality,

lity, we should be inclined to think our imitation not unlikely, in some measure, to supply the want of it in these cases. Astringents have, of late years, been found particularly serviceable in this disorder, and this quality our artificial composition possesses in a high degree, which may be still farther increased, at the same time that its heating effects are not so remarkable, on account of its laxative qualities. By this, however, we only mean, such cases as have no marks of a considerable calculus being already formed, and are not attended with any signs of fever, or inflammation of the part, as in both, or either of these cases, the native Bath water, and our imitation of it, would be equally improper. In all cases, likewise, where the stomach is drawn into consent during the nephritic proxyism, and retchings to vomit, nausea, &c. are the consequent symptoms attending it, the use of our preparation would be by no means likely to succeed, as it is at best but disagreeable in taste, and, at such a season, would probably serve only to aggravate the

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symptoms before mentioned, which we ought, by all means, to attempt to alleviate. Moreover, as these circumstances are generally attended with some degree of fever, the stimulus of the strong chalybeate would then be highly improper.

The cases that seem best suited to a trial of this kind, and indeed to the Bath waters themselves, seem to be of those who are subject at times to slight gravelly complaints, yet without any reason to think a calculus is really formed. If used in the intervals of these paroxysms, it may be of service, acting as a gentle stimulus to the organs of secretion, and promoting the urinary as well as abdominal discharges. By these means the gravelly concretions might be either prevented, (as they seem sometimes owing to too long a stay of the urine in the body, as we see those most liable to it, who, from necessity or any other cause, have been accustomed to retain
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their water a long time,) or at least discharged as soon as formed. In disorders wherein the stimulating qualities of the Bath waters seem to be most efficacious, as in paralytic complaints, it is not easy to determine how far our artificial preparation would be qualified to supply their place. The fixed air in these cases seems to be the most efficacious part of their composition, and it is not certainly known what proportion of this ingredient the native Bath water and our preparation bear to one another. It has even of late been made a doubt, if the fixed air itself be not diversified in its qualities, according to the substances from which it is procured. If this be true, we can have no security of any artificial composition whatever resembling the Bath water in this respect, as we know not by what means the latter becomes thus impregnated. There does not, however, seem to be any good grounds for such an opinion. As, however, the chalybeate impreg-

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nation is of itself a stimulating substance, and as the artificial preparation possesses this, as well as fixed air in large quantity, which last, in the state in which it is in the preparation under our consideration, possesses qualities similar to those that reside in the Bath waters, we cannot help thinking it, in such cases, from analogy of its contents, worthy a trial. It seems most likely to succeed in those cases where the stomach was little at least obviously affected. The eccoprotic qualities of this composition seem likely to be of great service here. Most of those who have any degree of this disorder are of a costive habit, which is by no means a favourable circumstance towards its cure. In order to obviate this, they are obliged to have recourse to purgatives. Those, however, of the stronger, or more drastic kind, afford only a temporary relief, and frequently add to the evil they were intended to redress, as, after their operation is over, the costive habit

habit returns in a greater degree, and the body is weakened by the operation of the cathartic; which is a circumstance by all means to be avoided. On this account, the milder purgatives have generally been made choice of. These, however, by frequent use become habitual, and require their dose to be increased, and if long continued are observed to weaken the tone of the intestines.

Could a medicine be found out, which would prove a constant, but gentle stimulus to the intestines, and at the same time, by its astringent and corroborating qualities, tend to restore their tonic powers, to the want of which, the costiveness in these cases is generally owing, it might prove a very happy combination of effects. We leave it to experience to determine, if the artificial preparation might not, in some degree, at least, answer both these purposes.

How this preparation might succeed in gouty complaints, for the cure of

which the Bath waters are so much famed, is still more difficult to conjecture. The intentions of cure vary so much in the several stages of this disorder, that scarce any medicine whatever can be said to be universally of service.

In what manner the native Bath waters act in this disorder, is very difficult to determine, as their good effects seem generally to be produced without any apparent operation on the body. Their *modus operandi* here is very difficult to explain, nor can that ever be satisfactorily done, until the cause of the gout itself be discovered.

Unfortunately, however, for medicine, very little progress has been made in this investigation of the nature of this disorder, nor (which is of more consequence) has any method of practice been established in it, of which the faculty of physic have any great reason to boast, notwithstanding it has been treated on a
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footing of this kind, at least as much as any one incident to the human species. The efficacy, however, of these celebrated waters, has never been doubted, though the practice relative to them, in this complaint, has been hitherto, in a great measure, empirical.

How the artificial composition may resemble them in their good effects, is not possible for us to determine, as experience is the only guide we can rely on in this case.

If, however, we may be allowed to conjecture, as it seems to resemble the Bath water in many of its qualities, it is not improbable it might be of service here. If the action of the Bath waters be in restoring the tone of the stomach and intestines, which are generally particularly affected in this disorder, we should not think this medicine ill qualified to answer such an intention, as it contains the fixed air and chalybeate impregnation in large proportion, both
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which are very efficacious in this respect.

One great inconvenience, however, the artificial preparation would be liable to: In gouty complaints, the native Bath waters are observed to be remarkably efficacious in removing the seat of the disorder from the head and stomach to the extremities. When this is the case, nausea and vomitings are generally concomitant symptoms, and these the Bath water seems peculiarly to relieve, and is frequently the only substance which the stomach can be induced to retain. In all probability, their being of a taste almost universally acceptable, is a great source of this quality.

In this circumstance, indeed, our imitation falls far short of the original, and until this deficiency can be supplied, which, at present, does not seem likely, we can have little hopes of its proving of equal efficacy in the cure of this disorder.

Moreover, as the gout attacks those generally, who have been accustomed to great indulgence of their palate, we are apt to think, that few of those who owe their disorder to this cause, would be inclined to make a sufficient trial of a medicine that had so little to recommend it in that respect.

Fortunately, however, this disorder falls chiefly on those who have it in their power to make a trial of the Bath waters themselves, and to these we would always recommend them, in preference to any imitation. As, however, the gout sometimes attacks the lower ranks of life, and many such as we cannot suppose have it in their power to make the experiment, to these a trial of our imitation of them might not be improperly recommended. If drank diluted, in the manner before mentioned, during the intervals of the fit, it might possibly be of service in shortening their duration, and rendering them more tolerable.

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One circumstance seems to recommend its use in this, and several other complaints, which is, that, if drank with the general cautions above mentioned, no harm is likely to accrue from it.

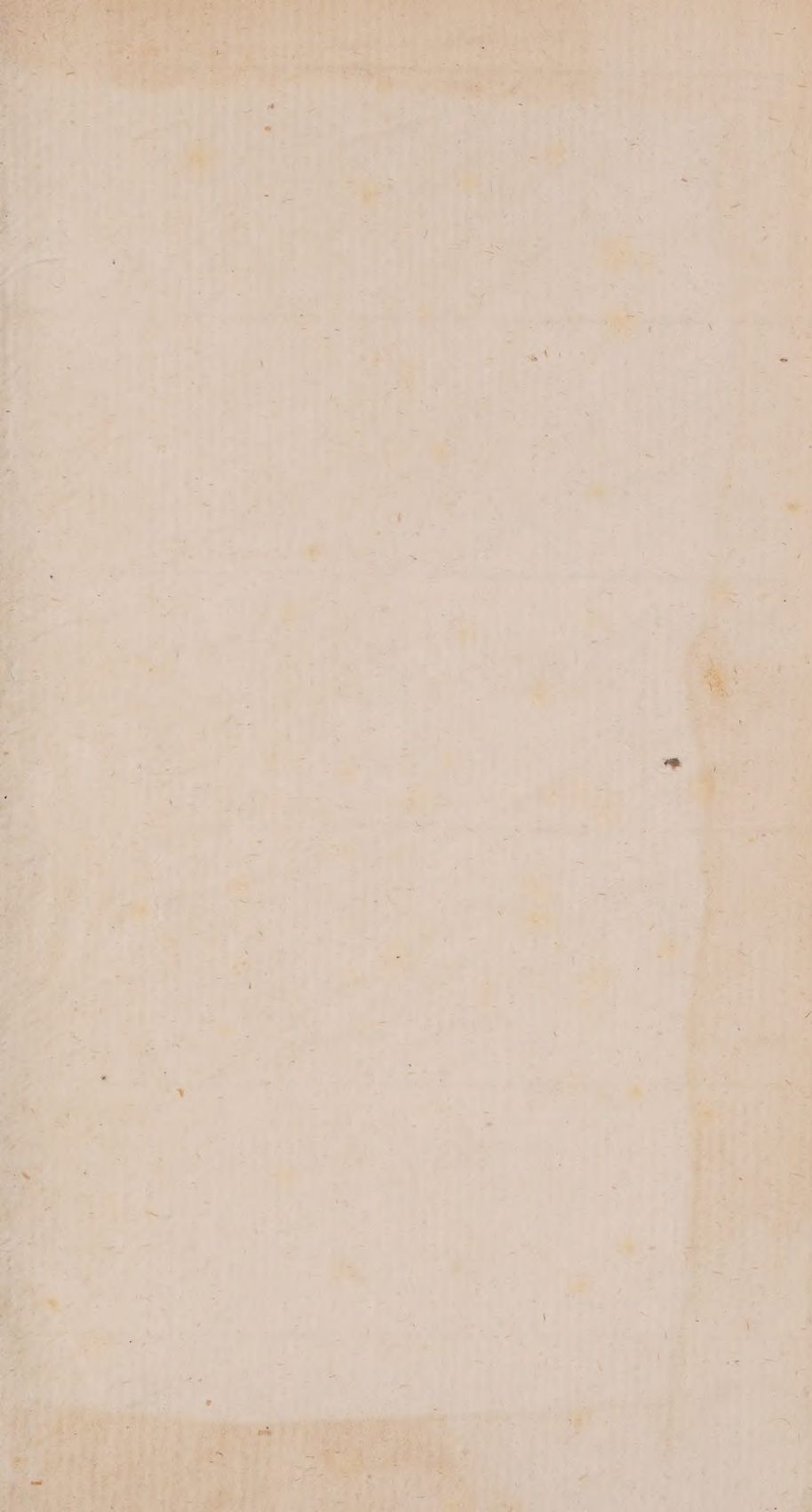
We have thus gone over, in a cursory manner, the general disorders in which the Bath waters are found of use, and those rather more particularly, in which the last mentioned preparation was likely to be of service. Perhaps it may be thought that we have delivered our thoughts on this subject too freely, as we acknowledged that our opinions were unsupported by experience.

But we hope the candid Reader will recollect, what we said in a former part of this Work, that we suggest what has been here said, concerning the medicinal effects of our imitation of the Bath waters, only as hints that we think bear some appearance of probability; and do not expect, or wish, to see them made a foundation for general practice, until they
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are established on the firmer basis of experience.

We should now proceed to consider the hot and cross Bath waters, and the effects of all with respect to their external use, with a comparison of their qualities with one another. This, however, we propose as the subject of another Work.

F I N I S.



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